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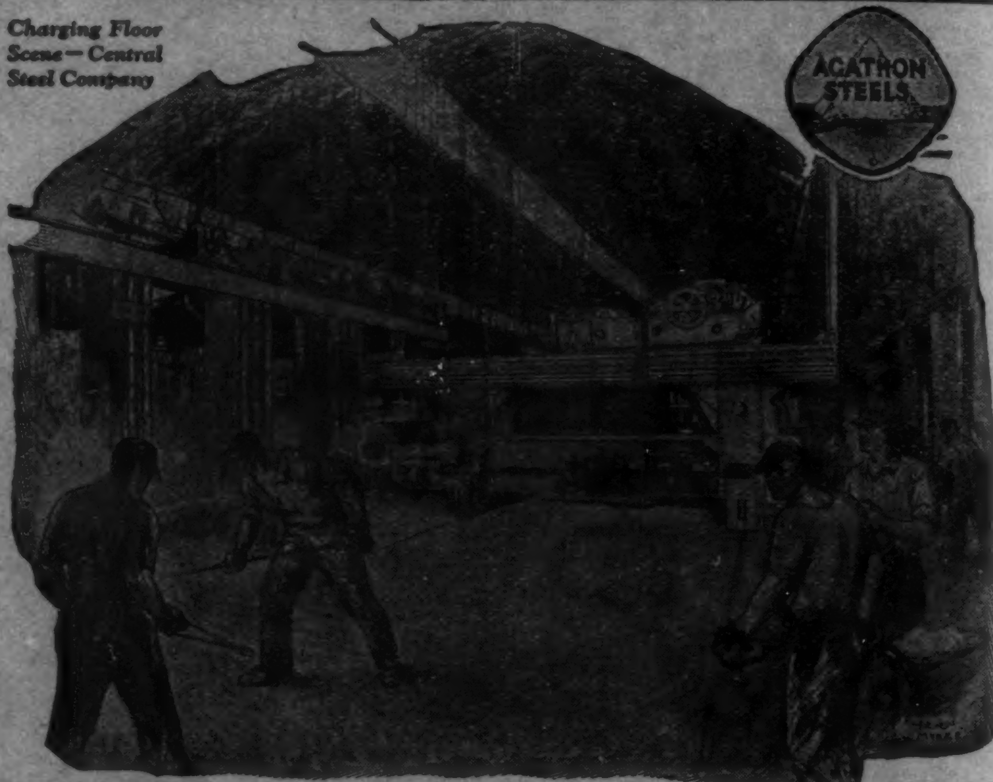
4600 Prospect Avenue

Charging Floor Scene — Central Steel Company



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AGATHON ALLOY STEELS

TRANSACTIONS

of the

American Society for Steel Treating

Vol. III Cleveland, December 1922 No. 3

GOOD ADVICE

WE ARE pleased to note an editorial published in the November issue of the *Railway Mechanical Engineer,* in which it was pointed out that the railroads of the country are not profiting as much as they should from the results of the activities of certain technical Societies and especially the American Society for Steel Treating. This editorial pointed out that considerable numbers of the papers presented at the annual convention of the American Society for Steel Treating held in Detroit and much of the discussion pertained to the production, forging and heat treating problems which are seldom presented to railway men, and that a large amount of the information which was brought out would prove of immense value when applied to ordinary railroad practice. Simply because railroad shops are operated for the most part as repair units is no reason why they should not be conducted on a business basis, and no modern business man, doing as much forging and heating work as the mechanical department men on the railroads do, would miss an opportunity to attend the conventions mentioned and keep in touch with the latest thoughts along forging and heat treating lines.

It was pointed out that the railroads should encourage their blacksmith foremen, heat treaters and forging experts to become members of the American Society for Steel Treating, and attend these conventions in order that they may benefit by hearing the papers on case-hardening, heat-treating, furnace construction, flow of metal under pressure, etc. The information which they would bring back to their shops and incorporate in local shop practice at the earliest possible opportunity would unquestionably save the railroads large amounts of money annually. These men should be allowed time and expenses for the trip, as is done by industrial concerns, because while it is true that the men benefit personally by the information and knowledge obtained, a far greater benefit accrues to the railroad which uses their knowledge. While all this is largely "water over the dam" as far as this year's conventions are concerned, responsible mechanical departmental officers should consider whether they have not missed a valuable opportunity to save money for the railroads by too rigid limitation of expense accounts. It has been suggested that steps should be taken to insure a good representation of railroad men at the American Society for Steel Treating convention next year.

One could count on their fingers the number of railroad men who are members of the American Society for Steel Treating. And this is not at all because they have not been approached on the subject but it is due largely to their indifference in the matter of accepting new ideas and profiting

thereby. It can be conservatively stated that more than a million dollars per year are wasted by the railroads through the use of dilapidated shop forging and heat treating equipment, thus depriving the shopmen the use of up-to-date equipment in the pursuance of their daily tasks. Therefore we, too, feel the American railroads could benefit very largely by studying the work that has been done recently in the use of alloy steel and thus lighten to a material extent the dead weight of their rolling equipment by the use of heat-treated alloy steels.

NATIONAL COMMITTEES

THE attention of the membership is directed to the National Committees appointed by President Lynch and published on page 28 of the TRANSACTIONS. In some committees there has been no radical change in the personnel, particularly in the Publication committee where the valuable services of the members have been continued.

President Lynch from his experience as chairman of the Standards committee last year has completely remodeled it and established a committee along larger lines. In the past, the committee has been composed of three members and while they have done very valuable work in formulating a program the committee was found too small to accomplish desired results, consequently, this year it has been enlarged until at the present time it has 26 members with Robert M. Bird, Engineer of Tests, Bethlehem Steel Company, as general chairman.

The committee is divided into four Sub-Committees on Recommended Practices: (1) for the heat treatment of tool steel; (2) for the heat treatment of steel—general (not including tool steel); (3) on case hardening; (4) on pyrometry.

The Chairman of each of the sub-committees together with the General Chairman form the governing board of the committee. One of the interesting things to note with reference to the President's new plan for this committee is that the members of each of the sub-committees have been selected from the same territory which will of course facilitate more frequent meetings.

The A. S. S. T. has every reason to be proud of the 294 members serving on more than 40 technical and administrative committees in the preparation of standards, reports, professional papers, meetings, research work and the dissemination of literature for the advancement of the metallurgical profession and the steel industry. Of this number, 146 are on national committees and 148 are serving on local committees.

The average member of the A. S. S. T. believes that true values are not measured by what he gets but by what he gives and that men of varying attainments, who have been more or less fortunate in the world are glad of the opportunity to share their success with others.

This is indicated by the fact that President Lynch did not receive a single refusal from any member whom he appointed upon his committees. It has been this wonderful spirit that has brought the Society to the front ranks of the profession it represents and with the continuation of this unprecedented co-operation great achievements will result from the work of the A. S. S. T.

COMPARISON OF AMERICAN AND ENGLISH METHODS OF PRODUCING HIGH GRADE CRUCIBLE STEEL

By T. Holland Nelson

SWEDISH iron in its natural condition containing, as it does, approximately 0.05 to 0.15 per cent carbon was of little use as a tool steel and to convert this, or in other words, to introduce a higher percentage of carbon, the soft bars were packed in alternating layers with charcoal into a converting furnace. This process is nothing more than a form of case hardening. The carbon content and the depth of penetration are entirely controlled by time and temperature. The average cementation furnace would take approximately three or four days to reach a temperature of 950 to 1000 degrees Cent. (1740 to 1830 degrees Fahr.) For ordinary mild heats this temperature would be maintained for six to seven days and for the hardest or razor steel temper anywhere from 11 to 14 days, and, occasionally, to obtain what is known as double converted bar some of the hardest material would be put in again and submitted to the same operation. After allowing the furnace to cool down, the bars were withdrawn and graded by the fracture into the varying degrees of hardness, which, of course, is correlative to either the depth of penetration or the carbon content.

As an example a converted bar was selected and after cleaning the scale from the bar, a series of chips were taken with a planing machine. From the outside to the center 12 cuts were taken, each having a depth of 0.02 inch, then in each cut the carbon was determined. The results obtained were:

Cut No.		Depth into Bar In.	Mean Carbon Content	
1	Outside	.02	.98	per cent
2	"	.04	.95	"
3	"	.06	.76	"
4	"	.08	.63	"
5	"	.10	.50	"
6	Medium	.12	.39	"
7	"	.14	.37	"
8	"	.16	.31	"
9	"	.18	.18	"
10	"	.20	.15	"
11	"	.22	.10	"
12	Centre	.24	.10	"

The mean carbon in the half bar (of mild No. 2 bar) was .45 per cent.

It will now be seen why it is impossible to determine the carbon by chemical analysis. The carbon is not evenly dispersed throughout the bar.

It will be readily appreciated that by this process it was impossible to obtain material uniform from outside to center and to reduce this lack of uniformity to a negligible quantity the bars were taken in fives (or what was known as faggoted), heated to a welding heat and forged together. During the heating the faggot was repeatedly smothered with a flux composed of lime, borax and salt, to prevent oxidation and to assist the welding. After a satisfactory weld had been obtained the bar was bent over, or sheared, and again rewelded to itself. This was known as shear steel. If again sheared and welded to itself the material is known as double shear steel, signifying

A paper presented before a meeting of the Society. The author, T. Holland Nelson, is manager of Henry Disston & Sons, Inc., Philadelphia.

Acknowledgement is made to *Raw Materials* for the use of the cuts illustrating this paper.

that after welding it had been either sheared or twice sheared.

It was at this period of the tool steel industry that Benjamin Huntsman

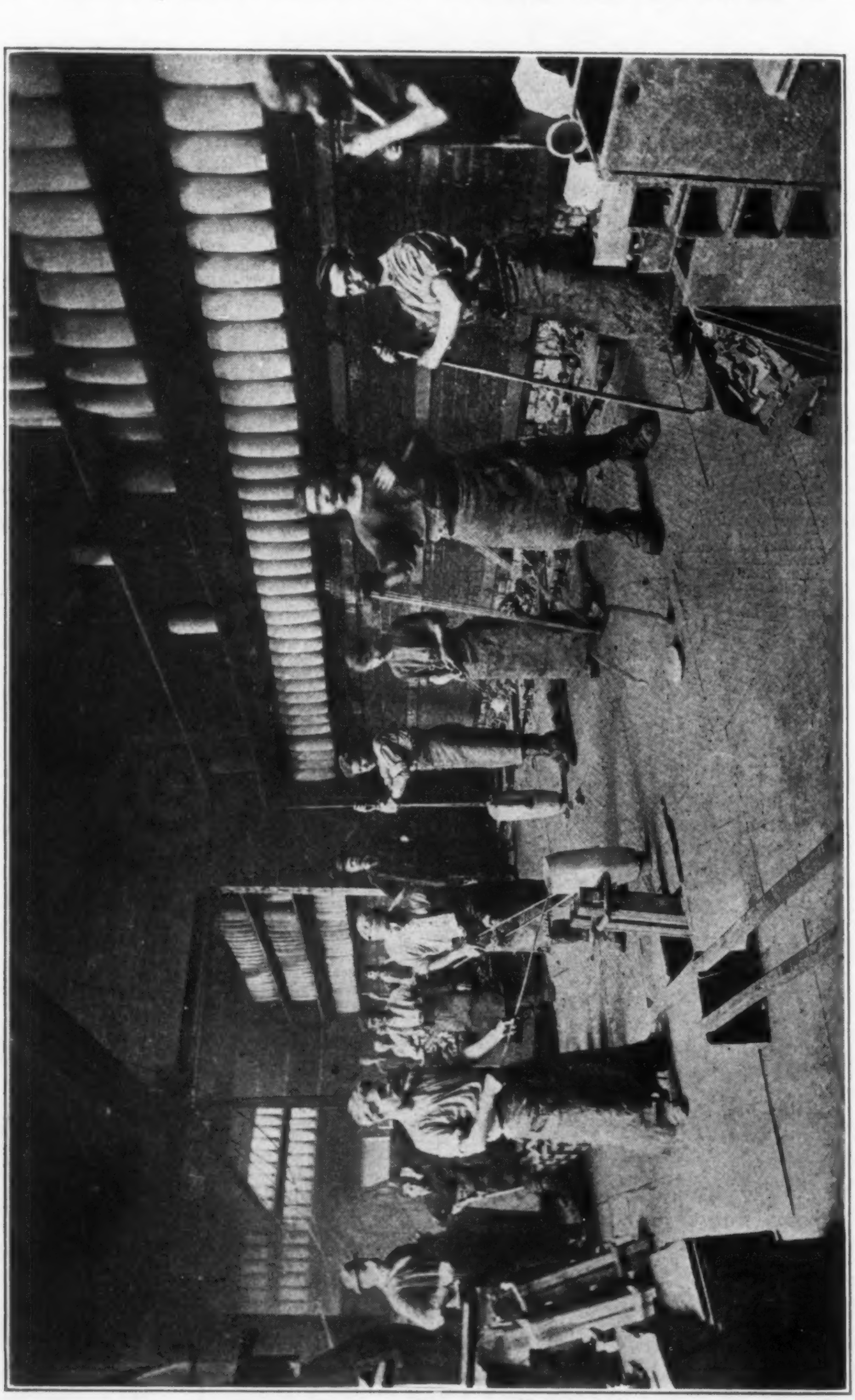

Fig. 1—Interior Crucible Furnace, "Teeming."

revolutionized it almost as completely as Taylor and White did at a later date when they perfected Robert Mushet's high-speed steel. Sheffield tradition

has it, and we have reason to believe this tradition to be correct, that Benjamin Huntsman was a maker of watch and clock springs, and having trouble with these springs, like many other people, (even today) he became so convinced of the correctness of his methods that he turned his attention to the steel and blamed the steel for all his troubles. In this respect, perhaps, we have many Benjamin Huntsmans still left. With a series of laminated bars of varying degrees of hardness there would be a distinct lack of uniformity which must have a bearing upon such delicate articles as clock and watch springs.

Huntsman carefully studied the then known methods of production such as has been outlined and conceived the idea that if it were possible to get the blister bar molten and poured into one solid mass the carbon would automatically become uniformly diffused and his watch and clock spring troubles thus be at an end. Finding little if any support for his theory among the local tradesmen he set to work to manufacture his own steel and he took as his base, blister bar broken up in small pieces, placed into an ordinary clay crucible, and melted by coke. From this early inception of the crucible process many improvements, modifications, and in some cases dangerous departures have been made. Huntsman's secret, as all other secrets, eventually leaked out and crucible steel today can claim many advantages over the original shear and double shear steel, but there are still some cases where the old fashioned article is found superior to the crucible steel, for it is not difficult to understand that with shear steel it was possible to obtain, owing to the irregular distribution of its carbon content, high carbon steel backed up by milder steel, or a combination of hardness and toughness so finely dispersed owing to the numerous welds that it is impossible to obtain by any other method. The nearest approach to it today is the variety of combined iron and steel sections used for different purposes where both hardness and toughness are required.

The coke-fired furnace and the clay pots were rapidly adopted in Sheffield. Some few gas-fired furnaces such as you have in this country have found their way into Sheffield, but the plumbago pot has not seriously been taken up. I can safely say that 80 per cent of the crucible tool steel, made in Sheffield is produced in coke-hole furnaces using clay pots.

Fig. 8 illustrates the method by which clay crucibles are made in Sheffield. A clay pot is made from a mixture of fireclay similar to the following:

Fig. 3—Water-wheel race at Clay Wheel Forge.

No. 1.	
5½ bags	Derby clay
2½ bags	Common clay
3½ bags	China clay
170 lb.	Coke dust
No. 2.	
6 bags	Derby clay
3½ bags	China clay
1½ bags	Common fireclay
160 lb.	Coke dust
No. 3.	
5 bags	Derby clay
3½ bags	China clay
2½ bags	Common clay
160 lb.	Coke dust

These materials are mixed together with water, as far as possible with a shovel and then submitted to what is known as treading. This is done with

the bare feet and continued for periods up to two hours. Sheffield is a great place for individual prejudice; each particular pot maker has his own particular mixes of clay, his own idea of how much coke dust should go into the mix and a stipulated time when he will add water. In fact, he attempts to surround his own particular job with as much mystery as possible in the hope that should you at any time "fire" him the firm will go out of business. I have never known of this happening, but the attitude of the operatives contrasts sharply with the open and frank way in which the writer has always found matters discussed in this country. The clay is made into a ball and then dropped into a flask; a plug is then hammered (Fig. 9) with a wooden hammer into the material, and the shape thus formed. The moist clay pot is forced out of the flask by means of a ram and the incurve at the top formed by using a small hand dish.

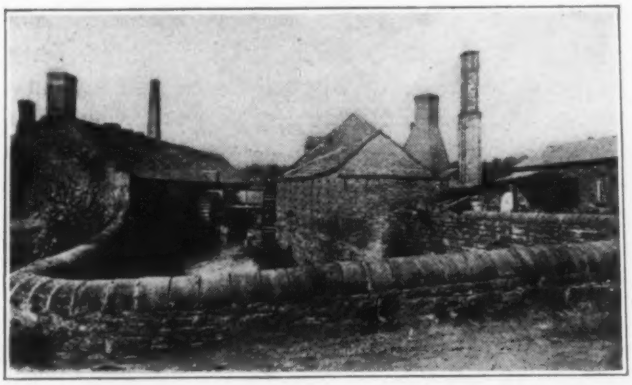

Fig. 2—Dam at Clay Wheel Forge.

The pots are taken invariably to the back of the crucible furnace stacks

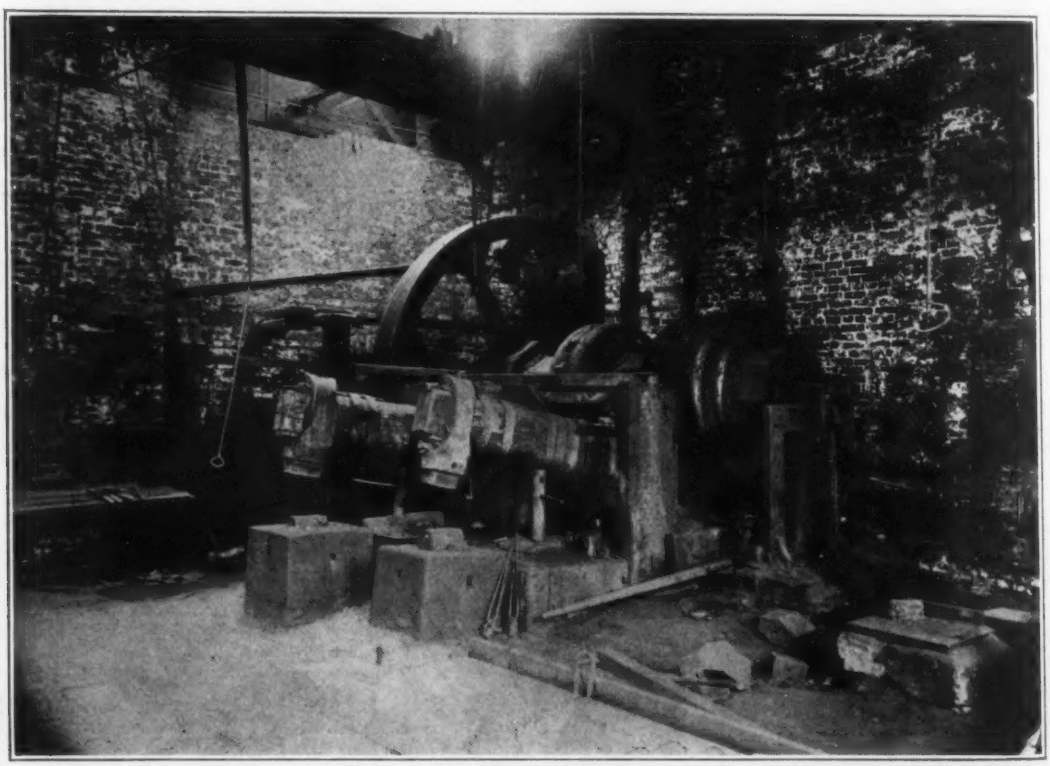

Fig. 4—Eighteenth century water-wheel "tail hammer" still in existence at the works of Peter Stubs, Ltd., near Sheffield, England.

and then day by day moved to a warmer position in the furnace, the drying process altogether taking about 21 days. Excellent pots are produced in this manner, one man and a boy being capable of making 65 to 75 pots per day

and each pot capable of melting three rounds of steel per day. Owing to the fact that the clay pots are extremely fragile when cold, they are made in close proximity to the furnace. As a result of this it is not at all uncommon to find one pot maker working for one concern Monday and Tuesday, for another Wednesday and Thursday, and so on. Fig. 10 shows a core box and charger as used in England. These are two extremely important articles. As will be seen from the cross section of a Sheffield coke-fired furnace shown in Fig. 11, this type of furnace is controlled entirely by the "flues" and the height of the stack. It has natural draught only and yet it is remarkable to what extent the heat can be controlled. A furnace crew consists of:

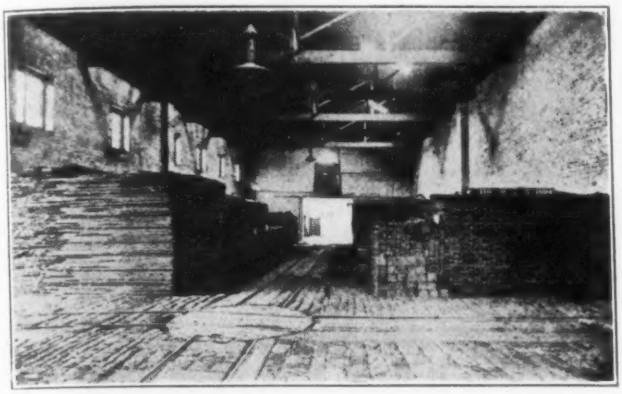

Fig. 5—A stock of 2000 tons of finest Swedish bar iron.

1 Melter or teemer
2 Puller-outs
2 Cokers
1 Odd man
1 Cellar boy.

The life of the English crucible hole is pretty steady at four weeks. If high carbon steels only are being melted, five weeks could be gotten out of them, but generally speaking, they are knocked and relined every fourth Monday. The relining takes one day, known as "building day," and is usually paid for as a full melting day's work.

At six o'clock every morning work commences with the cleaning out or "slagging" of the walls of the hole. The firebars are then placed in position, a half firebrick or stand placed in the position that the crucibles will ultimately occupy, and a shovel full of fire thrown into the bottom of the hole, thus burying the stand. When the whole 12 holes have been thus treated, the stands or half-firebricks are made bare with a scraper, the clay crucibles withdrawn from an annealing furnace at a dull red heat, and

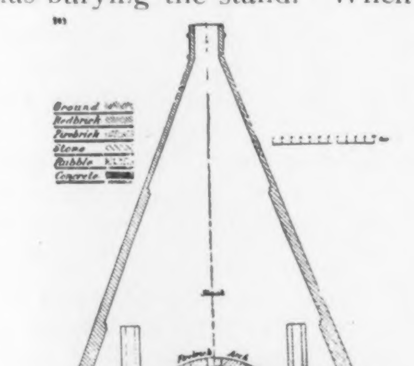

Fig. 6—Sectional diagram of the interior of a cementation, or converting furnace.

Fig. 7—Exterior of a cementation, or converting furnace.

placed upon these stands, care being taken that they are set perfectly straight. Coke is then packed around the pots, up to the lid, the cover placed upon the furnace and it is allowed to burn up. When the furnace has reached a nice heat, and it is essential that this heat be uniform throughout the pot, a handful or so of ordinary sand is thrown into the pot (which has a hole in the bottom). Coke is again added and the heat brought up to a temperature capable of melting the sand, thus cementing the clay crucible to the fireclay half-brick or stand. By this means a reinforced bottom is obtained, and the pot has accepted its own working level for the first heat.

As soon as the sand has fritted or cemented the crucible to the firebrick base, the puller-out turns off the pot lids, the charger or funnel is placed over the pot and the mix added. The lid is then replaced and the melting commenced in earnest.

Coke is added up to the flue line and gradually burns down. When fairly well burned down the puller-out goes over each hole knocking down any larger pieces of coke that may be adhering to the pot or that may be jammed between the crucible and the walls of the furnace. A second addition of coke, or fire, as it is termed, is made and the furnace allowed to travel. During this heat, the metal in the crucible will become first plastic, or be part molten and part pasty (it is at this period that a second steeling is made, where the whole of the mix would not go into the pot at one charge). A third fire or addition of coke is now made and in the ordinary run of things, when this is burned down the metal will be quite molten. This by no means infers that it is ready for teeming. Were it teemed at this juncture the material, containing, as it does, occluded gases, would be full of blow holes, it would boil over the mold on pouring and be quite spongy. At this and subsequent periods of the melt, considerable difference of opinion sets in as to the best method. The old method adopted for the removal of these gases was to keep the metal molten for various periods of time, with mild steel say, from one hour to one and a half; with harder steels, such as file steels, say, 45 minutes. This was left to the discretion of the melter, who was best able to judge the condition of the furnace, etc.

Later came the use of aluminum, manganese, silicon, titanium, vanadium, and the various less well known alloys, and as the introduction of these assisted to remove the gases in the steel, the time of the melt was reduced and there was, of course, a consequent saving of coke.

Personal experience in Sheffield has taught that the majority of firms use a combination of time, aluminum, and manganese.

The addition of approximately three ounces of manganese (80 per cent ferromanganese) and a killing fire lasting about 45 minutes, will deoxidize or remove the most obstinate gases. Therefore, this practice is pretty well standard. Some firms have their own particular fads and fancies. Titanium has been found useful; vanadium has, of course, other uses besides that of deoxidizing and to use it solely for this purpose would be very expensive.

Aluminum is the most powerful deoxidizer in general use, and one-eighth of an ounce will be sufficient to use with 100 pounds of liquid steel. Sometimes this is added with the ferromanganese before the last or killing fire goes on, but more often a small pellet of about this weight is thrown into the crucible after the flux or scum has been removed and the metal is ready for teeming. Occasionally I have known melters to add aluminum in the mold but this practice is not any too desirable.

When the melter has approved the last pot as sufficiently dead-melted to

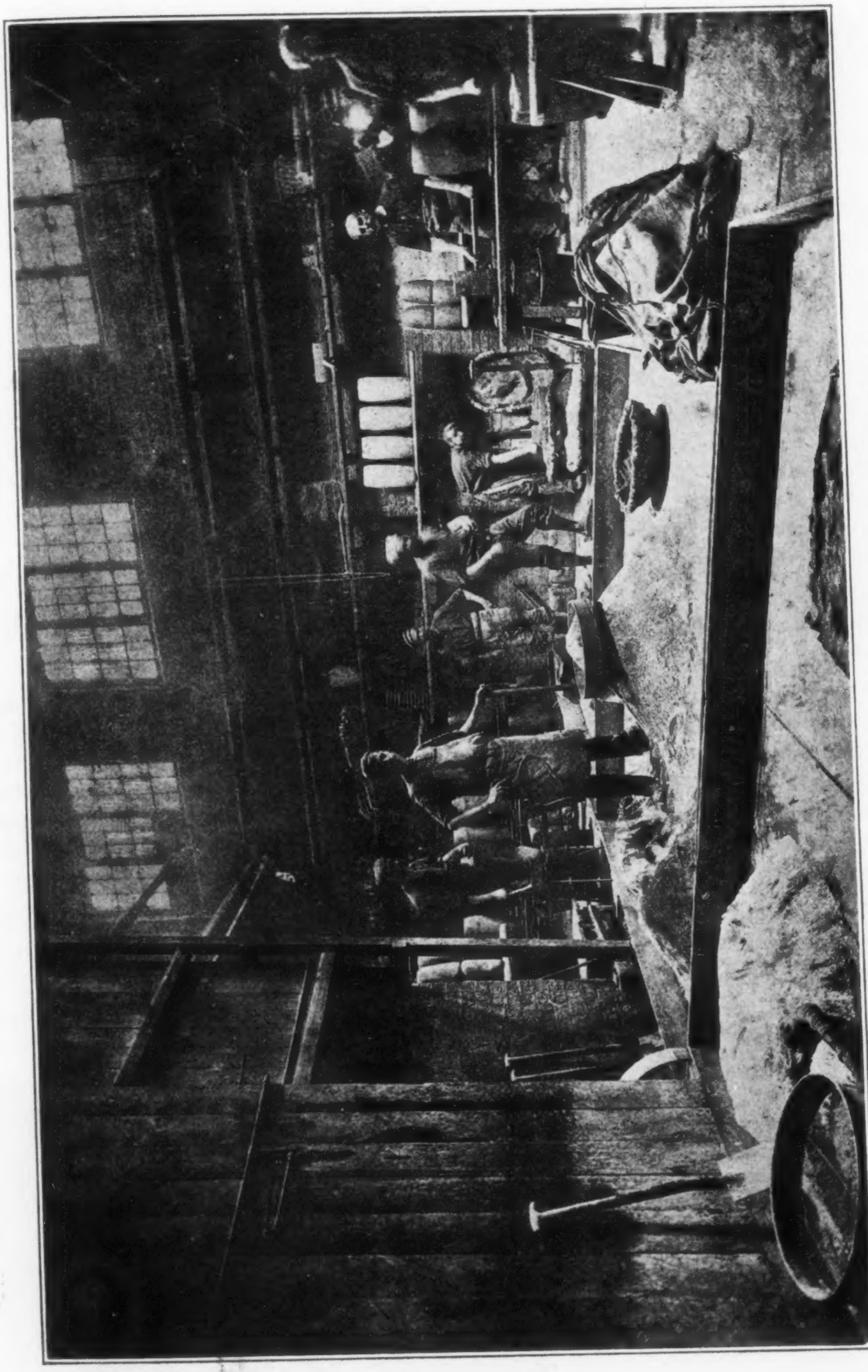

Fig. 8—This illustrates the method of making clay crucibles in Sheffield.

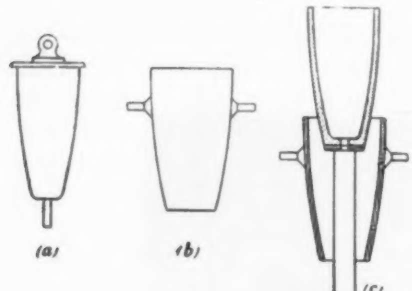

Fig. 9—Plug and flask for molding crucibles by hand. a—plug; b—flask; c—method of stripping crucible from flask; d—finished crucible.

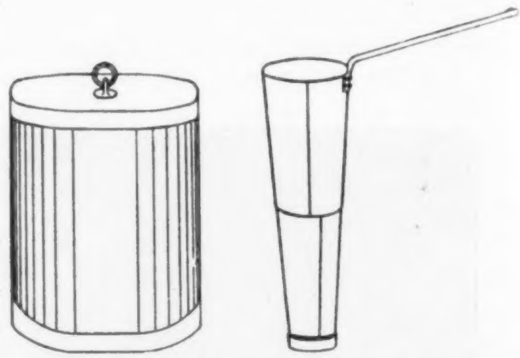

Fig. 10—The core box and charger as used in England are extremely important articles.

withdraw, the puller-outs commence to withdraw their pots, as far as possible, in the order in which they melted, i. e. if there was a pot slow in melting it would be left until the last as from start to finish in teeming a 12-hole crucible furnace, at least 20 minutes will elapse, so that often this interval will allow a doubtful pot to come up satisfactorily.

The second and third heat of the day's work are, in principle, exactly similar to the first, except that the furnace is already hot, the same pots are set back immediately after the teemer has emptied them and while still hot, (for they are as brittle as glass when cold) coke is added up to the level of the lid, so that when the teemer has finished pouring his last pot, the first one he teemed is ready to take the second charge of material and so the day's work proceeds.

As the ingot is teemed, a hot top or dozzle, as it is called in Sheffield, is placed at the top. This, being made of a refractory material, maintains the heat of the metal therein, which in turn feeds down into the shrinkage cavity or pipe which forms on cooling cold, according to the class of steel being made, the dozzle knocked off, as illustrated in Fig. 14. Surface defects are chipped or ground out, and the first part of the manufacture of crucible steel has been accomplished.

A Sheffield coke-hole crucible furnace works only in the day time. Prior to the war a day's work consisted of three rounds of "heats" of carbon steel and thus the furnace is allowed to cool down over night. That is, undoubtedly, a wicked waste of both time and heat, but it always has been, and, probably will continue to be as long as the coke hole

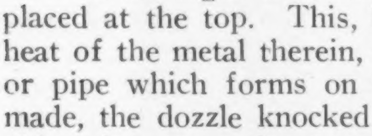

Fig. 11—Section through a Sheffield coke-fired furnace.

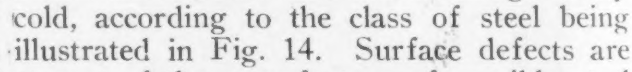

Fig. 12—Interior view of a large crucible steel 100-hole melting furnace at Norfolk Works, 163 feet long by 70 feet wide.

remains in use. Continuous running would of course slag up the holes, but it is certain these minor difficulties could be overcome. Nothing, however, has been seriously attempted in this direction and so they continue to work by day and sleep by night as the Lord originally arranged. The output of a coke-hole furnace, running three rounds, would be approximately 4560 pounds. Running, as now, for two heats only 3210 pounds. An American 30-pot gas furnace, running six heats in 24 hours, would produce 18,000 pounds. In Sheffield, the ingot is now passed on, in nine cases out of ten, to the forge. In America, where tonnage and production seem to come first, blooming mills appear to have the preference.

Fig. 13—Teeming in a Sheffield coke-fired furnace.

There is a great deal of argument, as to whether rolled steel is or is not as good as hammered. The writer will content himself with saying that for the most part the people advocating rolled steel invariably have no forge and likewise those advocating hammered stock, invariably are the better fitted to execute orders in that way. The writer's own opinion is that undoubtedly hammered tool steel bars are preferable every time. But by hammered bars, we do not mean bars as obtained here in many plants, where the bars are rolled to within a very slight margin of their finished size and then just hammered sufficiently to leave the impression of the die and so deceive the customer. This trick is not unknown in England, but the customer is pretty near as wise over there as the manufacturer and it would be difficult to get away with. To those buyers, if there may be any here, we would say that unless you know your material is hammered, keep the additional cost in your own pocket, for we can assure you that a bar just planished up as suggested is no better than a bar rolled outright.

The cogging, and ultimate hammering or rolling, is given great care and attention, overheating is strictly guarded against, while decarbonized tool steel forms a very small percentage of the Sheffield output.

The annealing and final inspection and shipment of the material does not differ from the general practice here. The Brinnell hardness test is in general use and is regarded as a simple, reliable, and efficient test for detecting any lack of uniformity in the condition of any batch of material. Time will not permit of dwelling further upon English methods therefore, we will outline the detail method in general use in this country, from which you will see many striking differences. Despite the fact that

Fig. 14—Topping and grading in Sheffield.

the writer is an Englishman he must admit that the production of crucible steel in this country is carried out upon a considerably more elaborate and scientific plan. Certain natural resources which are readily found in England do not exist here, but science and engineering together have done their utmost to overcome this natural handicap.

The American method of production differs in three great essentials from the English. As previously mentioned, in this country the gas-fired furnace is in general use. The three differences are:

1 Source of heat;
2 The furnace itself;
3 The crucible pot.

Compare in your mind's eye the simple coke-hole furnace previously referred to with the elaborate, though highly efficient furnaces illustrated in Figs. 17 and 18.

The source of heat of the design of furnace in use in the works of the plant with which the writer is connected, is the gas producer. There is a difference of opinion even on the arrangement in this country of the gas producer to the furnace, some concerns preferring the producer to be in direct working with its own furnace, whereas others favor a battery of gas

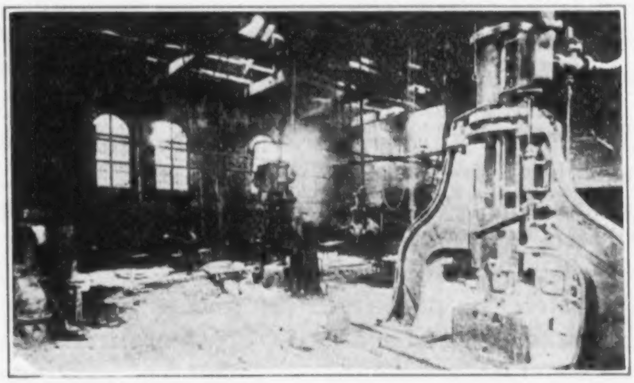

Fig. 15—Small Hammer for Crucible Steel Forging and Tilting.

producers supplying one large main and thence diverted to each respective furnace.

The main claim advanced for direct connection is that the producer can work entirely with the furnace and that the maximum heat can be given at exactly the time required. On the other hand, the chief claim in support of the battery producers, supplying one main, is that a supply of gas is always more or less uniform and if the plant is properly designed an ample supply of gas is always available.

This furnace consists of two or more melting pot holes, on each side of which are two regenerators for gas and air. The producer gas and air pass up through their respective chambers on each side, alternating during the melt, and produce a very satisfactory heating effect. As the melting hole across which the flame passes is very narrow, the gas and air combine and burn in the three narrow flues before entering the melting hole. The progress of the flame through the melting hole is also retarded by having the three inlet ports out of line with the three outlet ports on the opposite side of the melting chamber. A very intense heat is obtained in this manner, so much so that the cutting action of the flame upon the sides of the melting hole is

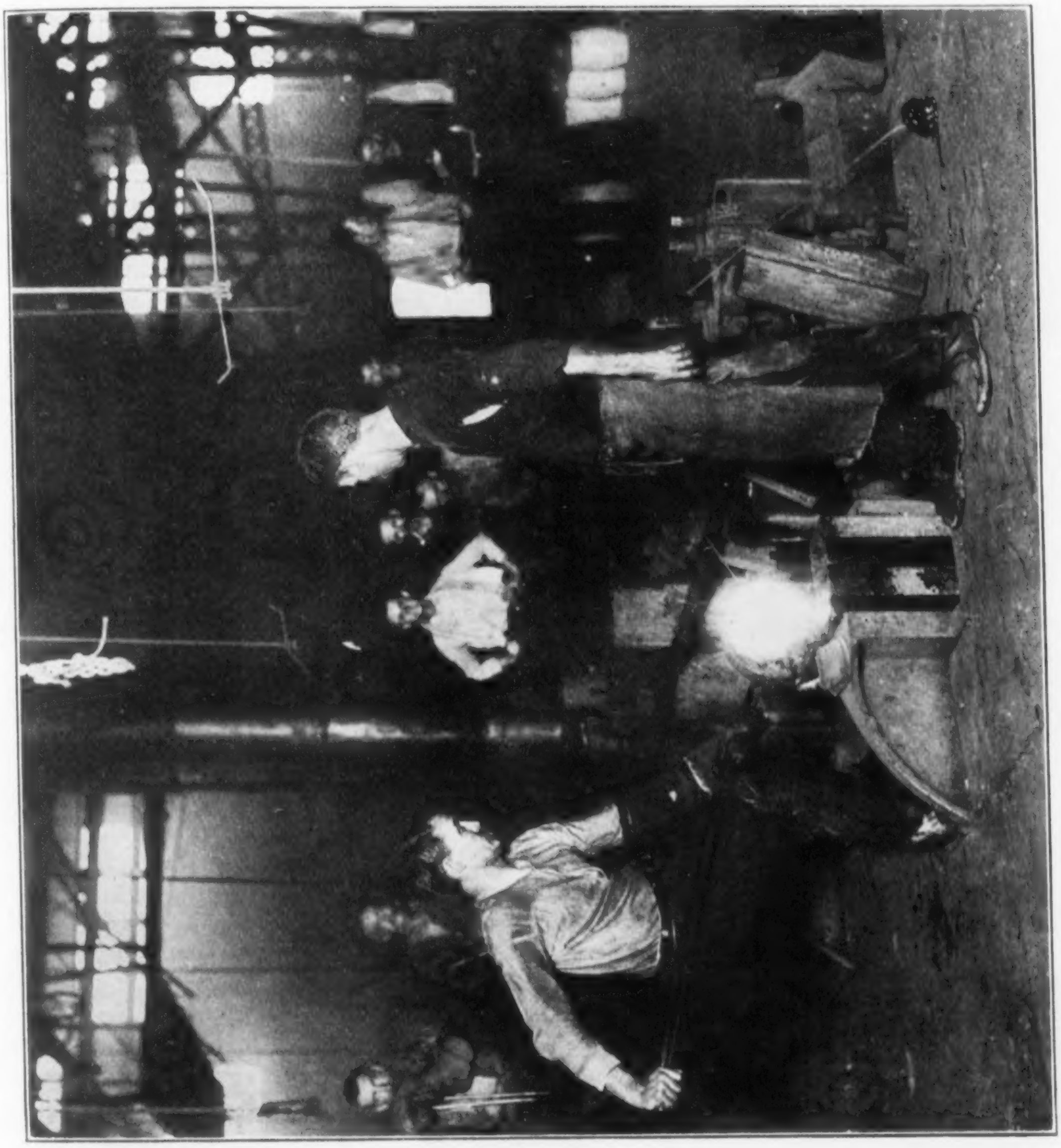

Fig. 16—Typical scene in a crucible steel plant.

most severe, necessitating the use of protecting bricks, which are made of the highest resisting silica fire-brick.

The form of the melting hole (Fig. 19) also encourages the concentration of the heat; the inclination of the brick work on each side of the chamber toward the top deflects the heat upon the crucibles. The crucibles stand on coke dust, which forms the bottom of the melting hole. At the bottom of the coke bed and in the center of the melting chamber, there is a hole which passes right through the brick and iron work forming the bed, to a vault below. This hole is usually covered with an old curcible clay lid, upon which the coke dust rests. Should an accident happen and a charge of steel be lost, a hole is made through the coke bed to the vault bed below, and the steel allowed to fall through. The coke bed is renewed and work proceeds again without much delay.

Fig. 17—Floor view of an American crucible steel furnace plant.

As a rule, two shifts are employed in working this furnace each gang obtaining three heats during the shift; the second gang relieves the first after the third heat is completed, at whatever hour that may be. The furnace works continuously from Monday morning till Saturday morning, when it is patched or repaired if necessary. A hole through the coke bed in the melting chamber is usually made every Saturday, and any clinker and steel from the furnace is pushed through the bottom, after which a fresh bed of coke dust is made.

Each melting chamber holds six crucibles, and is closed by three covers lined with firebrick. As each cover serves for two crucibles, it is unnecessary to move more than one at a time, when placing or removing the crucibles. The regulation of the gas and air is most important for producing uniform heating, which is sometimes very difficult to obtain throughout the melting hole without careful manipulation of the gas and air valves.

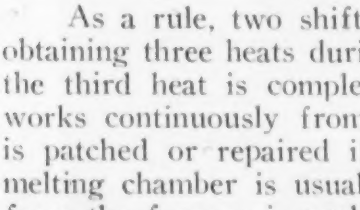

Fig. 18—Sectional view of a crucible steel furnace of an American manufacturer.

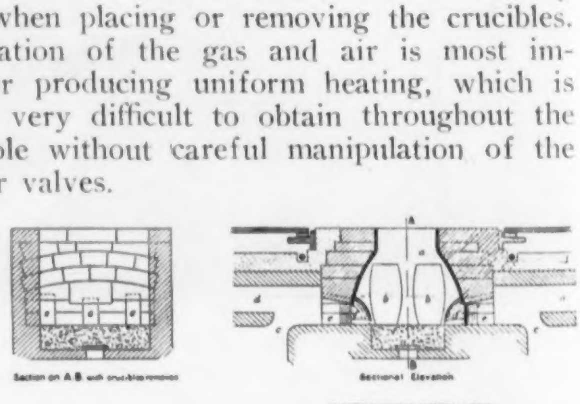

Fig. 19—Sectional diagram of a melting hole.

In America the method of introducing the material into the pots differs entirely from that operation in Sheffield. Here the plumbago pot is, with some firms, charged cold. In other cases they are filled hot and set back, it being claimed more heats are obtained in this way. The weight of the charge varies from 90 to 110 pounds.

The gas-fired furnace is much shallower than the coke-hole furnace, the depth being approximately 33 to 34 inches from the coke bed to the floor level, whereas, in the coke-hole furnace the depth from the fire bars to the floor level varies from 42 to 44 inches. This difference in depth is largely responsible for the fact that it is possible to melt 100 pound weights in America as against 70 pound weights in England.

The American puller-out is able to bring his pot onto the floor with a single lift, (Fig. 20) whereas in England, owing to the increased depth of the furnace, a double lift is necessary. The temperature of the American gas-fired furnace is controlled by gas and air valves, which method offers a striking contrast to the putting on of another basket-full of coke or the

Fig. 20—Drawing a heat.

Fig. 21—Manufacturing plumbago crucibles in the plant of an American crucible maker.

closing up of a flue with a fire brick, the only means in Sheffield practice of controlling the temperature. The life of the American furnace varies considerably according to the class of steel that is being melted. If a large percentage of high-speed steel or alloy steel is made, where correspondingly high temperatures are in general use, then naturally the life of the furnace is not nearly as long as it would be were the main product straight high carbon steel. It is quite safe to say that six months would be considered a very poor run while 12 months would be considered exceptionally good. As has been previously stated, the output of an American 30-pot gas-fired furnace would be for six heats, approximately 18,000 pounds in 24 hours.

The crucible pot is made of a different material entirely. In this country the plumbago or graphite pot is in general use. The analysis of this type of pot consisting of a mixture of Ceylon graphite and fire-clay would be somewhat as follows:

	Per Cent		Per Cent
Carbon	50	Alumina	11
Silica	35	Iron Oxide	4

In contrast with the English method, the manufacture of plumbago crucible pots in this country is an industry by itself. Through the courtesy of a Philadelphia crucible company, the writer is enabled to illustrate the final operation in the manufacture of the plumbago crucibles (Fig. 21). The mixture of fire-clays and graphite is scientifically carried out in a series of pug-mills and mixers and the necessary amount of the mixture or ball, as it is termed, is finally spun to shape in the mold.

A homogeneous mixture and a crucible pot with walls that are uniform is thus obtained. The annealing is carried out in bulk and as the plumbago pot is fairly tough and capable of transportation, the American steel manufacturer is able to purchase his crucible pots by the carload, ready for use. Contrast this with the English method of making clay pots which are so fragile that it is impossible to transport them, and their method of annealing over night is just sufficient for the next day's run. It is possible to obtain anything from five to ten heats with a plumbago pot, melting steel, but an average of seven would be considered quite good, which compared with the limit of three in England again draws attention to a comparison distinctly in favor of the American method of production.

Up to this point everything seems to be in favor of this country's methods. But it is at this point that one of the serious difficulties arises. This type of pot, offering as it does such an increased life, has its disadvantages. It is a mixture, as was said before, of refractory clays and graphite, of more or less pure carbon. This carbon is absorbed by the steel in its liquid condition and unfortunately it is not possible to say with any degree of certainty to what extent the carbon absorption will take place. With the English clay pot the degree of uniformity in the finished steel is really remarkable. The writer has personally taken 24 single ingots teemed from clay pots and found no greater variation in carbon content than 0.06 per cent. On the other hand 30 pots from American plumbago pot furnaces showed them to carry in carbon content as much as 0.30 per cent. This, as you will readily appreciate, is a very vital point, and American manufacturers realizing this, in a typical American way, set out to obviate this serious lack of uniformity.

Ladle teeming was introduced. The pots, instead of being teemed direct, are now invariably dumped into a ladle. Sometimes the entire 30 pots will be put into the ladle at once; in other cases, according to the discretion of the manufacturer, a 30-pot furnace will be split into two small ladles. Thus, by the introduction of ladle teeming, a degree of uniformity is established as close as that to which the English manufacturer can work. But, where direct teeming from the pot has to be used, undoubtedly the Englishman is able to work to a closer specification than the American. Ladle teeming is being split into two distinct methods. The one in most general use is known as bottom teeming and is illustrated in Fig. 22.

It is claimed for this process that the possibilities of slag inclusion are extremely remote. It should, however, be borne in mind the stream is controlled by the weight of metal behind it and it is not at all unusual to find the first few ingots cast by this method have very dirty surfaces due to splash. The other method, which is known as top or lip teeming (Fig. 23) although not in general use, the writer is of the opinion that much more satisfactory results are obtained. There are very few types in use, one or two in Germany, a few in Sheffield, England, and a few in this country. It is regretted that it is not possible to go into greater detail on this matter, but it will be seen that this method approaching so closely, as it does, to the hand teem-

ing operation, and obviating, as it does, the effect that a varying weight of metal behind the stream would have, it has every chance of giving results more closely similar to hand teeming than the bottom casting method. The ingot after casting is treated very similarly in this country, with the exception that a considerably larger percentage of material is rolled and in many cases never sees a forge or steam hammer at all.

To touch upon the most vital point in connection with the manufacture of crucible steel, we will refer to the class of material from which it is made. This is essentially the keynote of success or failure, or the production of good or bad steel, as much in one country as it is in the other. The writer can think of no phrase that boils the matter down so well as one used by Prof. Arnold of Sheffield University, who taught me in my younger days, and this phrase was: *If you put the devil in a crucible pot you will get the devil out.* If you give this phrase a second thought, you will see that it means a great deal.

Huntsman started with breaking up pure Swedish iron bars which had been converted in the presence of charcoal to the desired carbon content and remelted the mass in the crucible. No doubt, in the course of time Huntsman himself accumulated a supply of scrap and wondered what to do with it. Unfortunately we have no records to show whether he sold it to the junk man, or whether he introduced some small portions of it into his later steels. It is, however, an acknowledged fact in England that the higher a proportion of Swedish iron a mix contains, the better the quality of the ultimate steel. Desire for increased profits, keen competition, and other causes, have at one time or another prompted steel manufacturers in both countries to dilute their steel mixes. This can undoubtedly be carried too far. David Carnegie in his excellent book on *Liquid Steel* gives a few typical mixes. For high-speed steels he recommends Swedish iron entirely, with the necessary additions of tungsten, chrome, vanadium, etc. For ordinary carbon steel, he gives examples containing as much as 60 per cent Swedish iron, diluted with 40 per cent carbon steel scrap.

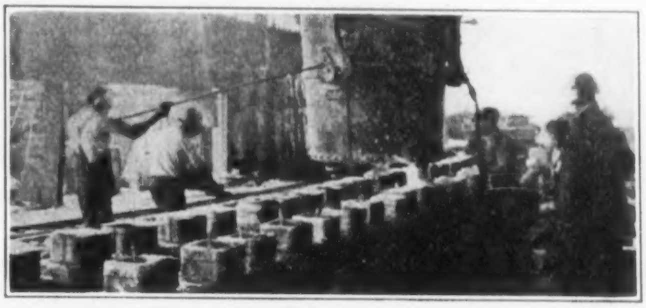

Fig. 22—Bottom teeming. Pouring the ingots.

Few writers and fewer steel manufacturers seem inclined either in their books or papers to give much information of mixes. It may, therefore, be of interest if a few hints on general practice in this direction are given. Such mixes as are mentioned, of course, are not the mixes of any one firm with whom the writer has been employed, for such would not be fair, but it will give you an idea how prices affect quality.

High-Grade Quality	
80 per cent Swedish Iron	Sometimes split in ratio 60 per cent Swedish and 20 per cent domestic.
20 per cent Carbon steel scrap	Usually of the same mix
Second Quality	
60 per cent Swedish iron	Split, say 40 per cent Swedish and
40 per cent Carbon steel scrap	20 per cent domestic.
Third Quality	
50 per cent Swedish iron	Split, say 30 per cent Swedish and
50 per cent Carbon steel scrap	20 per cent domestic.

Speaking of steel manufacturers in general, very few could obtain the price it would be necessary to ask for a quality higher than No. 1, and on the other hand, there is perhaps no reputable steel maker who would care to make crucible steel of a cheaper quality than No. 3.

The question of Swedish iron is a very broad one. In Sheffield, each particular firm jealously guards the brand of iron it uses. The writer's late employers had the exclusive use in England of "Big S," but as no more of this is now made, he is betraying no secret. Other irons in regular use are:

"W & Brown"	"L. T. S."	"J. M."
"Hoop L"	"L. G."	"B. F. S." etc.

All of these are good irons. You have here your own domestic irons the makers of which claim strongly that they are quite equal to Swedish.

During the war a great deal of domestic American iron was bought by

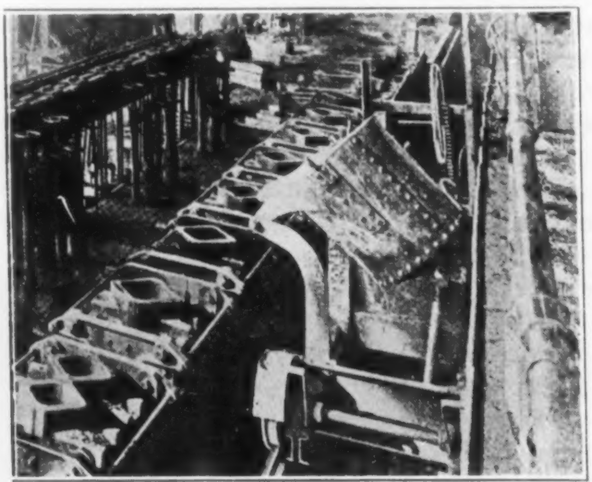

Fig. 23—Lip teeming.

the British Government and used in Sheffield, and our experience did not prove it equal to the Swedish.

As American iron is cheaper than Swedish, some firms over here use it entirely, but the wiser concerns and those with which quality counts, use Swedish or a combination of both.

Recently a metallurgist of a prominent firm in this country stated, when asked his opinion on Swedish and American irons, that the only advantage in Swedish iron was to be able to say you used it for the sake of the advertisement. The writer's opinion, based on 20 years' work with crucible steels, is that nothing equal to Swedish iron, as a base, has yet been found. That is why most of the foremost firms in the United States use it.

There are some people in a small way of business who believe they can put anything into a crucible, from old tires and rails downwards, and still call their product crucible steel, but I have no hesitation in saying that I would certainly prefer a piece of good basic open-hearth steel to a rotten and inferior piece of material even if it had the halo around it of having been melted in a crucible.

We have previously referred to the fact that production does not always coincide with service and quality, and that an attempt to standardize the tool steels of the world has as its primary object the increase and standardization

of production. As the writer is from that very conservative school which still holds the belief that there is a special steel for special purposes and a special steel for special conditions. To standardize steel alone would necessitate more or less the elimination of the human element and throw us entirely dependent upon mechanical or scientific control. Being a metallurgist, the writer realizes this as a beautiful "metallurgical dream," but by way of warning, we must not forget or for a moment lose sight of the fact that the human element and rule of thumb methods controlled the steel industry for many decades past, that the science of metallurgy is still in its infancy, and that day by day we have proof that works practice can cope with difficulties which metallurgical minds cannot altogether explain. Let us, therefore, try to bend our theories to meet proven facts, rather than attempt to bend works practice too much to meet our theories.

Analyses of a few high-grade alloy steels which were manufactured by the writer in England, and used for special purposes may not be out of place.

In England, practically all the leading tool-steel manufacturers produce three qualities of high-speed steel, something similar to the following:

Twist Drill

Carbon	0.50/0.70
Silicon	trace
Manganese	not over 0.20
Sulphur	low as possible
Phosphorus	low as possible
Chromium	2.50/3 per cent
Tungsten	12/14 per cent
Vanadium	Nil to trace

Standard

Carbon	0.55/0.65 per cent
Silicon	trace
Manganese	0.20 per cent
Sulphur	low as possible
Phosphorus	low as possible
Chromium	2.75/3.50 per cent
Tungsten	14/16 per cent
Vanadium	Nil to 0.50 per cent

Super.

Carbon	0.55/0.65 per cent
Silicon	trace
Manganese	0.20 per cent
Sulphur	low as possible
Phosphorus	low as possible
Chromium	3/4 per cent
Tungsten	16/18 per cent and sometimes up to 20 per cent
Vanadium	0.50/1 per cent

Molybdenum is used by some manufacturers in varying proportions from traces up to as high as 3.5 per cent. Of course, it will be remembered that Prof. Arnold recently caused a stir by claiming that a steel containing approximately 6.00 per cent molybdenum, without tungsten, had beaten an ordinary 18.00 per cent tungsten steel. However, 18.00 per cent tungsten steel still holds sway. Molybdenum is, nevertheless, an alloy worthy of special attention and will undoubtedly figure in no small way in the future.

Magnet Steel

	Per Cent
Carbon	0.55/0.65
Silicon	0.20 not over
Manganese	0.20 " "
Sulphur	0.025 " "
Phosphorus	0.025 " "
Tungsten	5.50/6

Purpose:

This steel is particularly suited to the manufacture of magnets for electric meters, magnetos for motor cars, telephone work, and all other purposes where the best steel obtainable is required.

Heat Treatment:

The hardening depends a great deal upon the exact purpose for which this class of steel is used but I have found the following to be most

satisfactory: Heat slowly and uniformly to a temperature in the neighborhood of 825 to 850 degrees Cent. (1510 to 1570 degrees Fahr.) i. e., a full bright red heat, and quench outright in clear cold water. If the article to be hardened is of intricate shape and design, warm water or even oil may be found desirable to quench in.

Special Alloy Steel

	Per Cent
Carbon	1.10/1.20
Silicon	0.20 not over
Manganese	0.20 " "
Sulphur	0.025 " "
Phosphorus	0.25 " "
Chrome	0.75/1
Tungsten	3/3.50
Vanadium	0.25

This steel is specially designed to meet the requirements of the machine shop where ordinary crucible cast steel is not satisfactory, and yet where a high-speed steel is not necessary. It is also a superior quality for roll turners' tools, and in instances where an extremely keen cutting edge is required, capable of withstanding heavy wear.

Heat Treatment:

This is another extremely delicate steel and requires considerable care in the heat treatment: It should be heated slowly and uniformly to a temperature of approximately 800 to 825 degrees Cent. (1480 to 1520 degrees Fahr.) and quenched in clear, cold or tepid water.

Combined Iron and Steel

Cast together—not welded.

		Per Cent
Iron:	Carbon	not over 0.20
	Silicon	not over 0.20
	Manganese	not over 0.20
	Sulphur	not over 0.025
	Phosphorus	not over 0.025
	Nickel	not over 0.25
Steel:	Carbon	0.85/0.90
	Silicon	0.20
	Manganese	0.20
	Sulphur	0.025 (not over)
	Phosphorus	0.025 (not over)
	Nickel	0.25

Stainless Steel

	Per Cent
Carbon	0.25/0.35
Silicon	0.20
Manganese	0.20
Sulphur	0.025
Phosphorus	0.025
Chromium	13/14
Nickel	Trace

This steel is used for cutlery, etc., and anywhere where non-corrosive and unstainable steel is required.

The heat treatment varies. It is generally hardened about 1050 degrees Cent. (1920 degrees Fahr.) and tempered up to 450 degrees Cent. (940 degrees Fahr.), according to requirements.

Wortle Plate or Drawing Die

	Per Cent
Carbon	1.50/2
Silicon	0.20
Manganese	0.20
Sulphur	0.025
Phosphorus	0.025
Chromium	12/12.50

Produced specially for drawing dies, where maximum hardness and abnormal wearing properties are essential.

Heat treatment: Although it is possible to harden this steel with great care in water, it is not generally adopted, satisfactory results being obtained by heating the material carefully and uniformly to a temperature of approximately 850 degrees Cent. (1570 degrees Fahr.) and quench in cold, clean oil.

Alloy Chisel

	Per Cent
Carbon	0.55
Silicon	0.20
Manganese	0.20
Sulphur	0.025
Phosphorus	0.025
Chromium	0.25/0.50
Tungsten	0.75/1

It is used for pneumatic chisels, etc., where a higher priced steel is warranted.

Heat treatment: Harden in oil or water from 775 degrees Cent. (1430 degrees Fahr.) and temper according to requirements.

Alloy Die Steel

	Per Cent
Carbon	0.65/0.70
Silicon	0.20
Manganese	0.20
Sulphur	0.025
Phosphorus	0.025
Chromium	0.25/0.50
Tungsten	0.75/1

This steel is for making dies and general press tool work.

Heat treatment: Harden in oil or water at approximately 775 degrees Cent. (1430 degrees Fahr.).

Hack Saw

	Per Cent
Carbon	1.10/1.20
Silicon	0.20
Manganese	0.20
Sulphur	Low as possible
Phosphorus	Low as possible
Tungsten	1.25/1.50
Chrome	traces/0.25

The heat treatment of this class of material is so generally known here that it is unnecessary to go into detail. Hardening and tempering vary according to the experience of the particular user.

Fig. 24—A series of mixes already weighed up showing in the front of the weigh pans the large percentage of Swedish iron used at the plant with which the author is associated.

The English method of crucible steel production is simple and the natural resources in clays, etc., result in a highly satisfactory and uniform material. The tonnage production is considerably lower, but so also is the cost of labor and particularly the cost of crucibles. A clay crucible costs about 2s 6d, i. e., 60 cents. The usual practice is for the firm to provide all raw materials and buildings to work in and the man then receives about 16 cents per pot, piece work.

Compare this with $5.00 per pot, which is the price of the average American crucible today.

But remember, also, how the output compares.

English 4500 pounds in 3 heats, or 3200 pounds in 2 heats.

American 18,000 pounds in 6 heats.

The introduction of ladle-teeming established a standard of uniformity in

American steels quite comparable with the English and so this difficulty was overcome.

As proof of this the fact that superfine steel can and is being produced in America is borne out by the fact that in Sheffield, England, American made saws are to be found, and assurance can be given Americans that their steel makers are in serious competition in every way with the Sheffield producers. The tremendous varieties of steels used in a saw, file and tool-steel works are proof of this statement.

The writer says without fear of contradiction that if the American manufacturer puts as good material into his crucible as his English or continental competitor, despite the difference in the methods of production, he can obtain quite as good a steel in the *ingot* with a considerably increased tonnage.

Undoubtedly there will be those who will wonder why, if my statement is correct, so much English steel is still imported by this country.

Some will say that in the first place the cause is due to the prejudice of certain toolsmiths, etc., who "swear by" certain brands of Sheffield steel and won't even try any other. Personal prejudice has always been a great influence, and this is, therefore, true in some cases, but there are other reasons.

Without wishing to deprecate the merits of American steels, the writer's candid and frank opinion is, that the chief fault is with the national desire all the time for *increased production, tonnage, tonnage, tonnage.*

This has led, in many cases, to the entire abandonment of hammering and the substituting of rolling. Speeding up of the mills has necessitated the raising of rolling temperatures with its consequent risk of overheating and decarbonization. Great care is taken to avoid decarbonization and overheating in England where the *steel maker* tells the *engineer* what he wants.

Here the production engineer more often tells the steel maker what the mills are geared up to and he has no alternative but to abuse the steel in the endeavor to keep pace.

Many American catalogs contain the advice to remove up to 1/8 inch to get off a decarbonized surface. A film of decarbonization will always exist, but to openly admit decarbonization to such an extent, is nothing short of calamity. "Open confession is good for the soul," but *these are some of the reasons* why some of your best toolsmiths prefer English steels. Results prove the latters' uniformity and its freedom from overheating and decarbonization. You can do it here, if you will. You have solved some of the big problems and placed yourselves as a nation ahead, so far as the mechanical end goes, then why let the metallurgical details spoil your productions? A word or two of advice to any American who puts quality first is to delve into the *metallurgical* details with the same energy and enthusiasm with which he approached the bigger *mechanical* problems.

Finally, let me urge the necessity of dealing only with houses of repute.

Urge upon your buying departments the folly of buying high-grade steels from unreliable sources, for a cent or a fraction of a cent per pound less.

Think how a cent or so difference in cost of a piece of steel may "make or mar" a very expensive finished machine tool.

Take your steel maker more into your confidence in placing specifications, for in many cases he is quite willing and able to help you in the selections of suitable steel.

STEEL IS STEEL

By C. F. Smart

TWO darkies were engaged in a technical discussion:

"Ain't steel an i'on jus the same?"

"Cose not, they diffahs."

"How so?"

"Well, steel has some i'on in it, but i'on is i'on an steel is steel".

This seems to be the idea of many people, and too frequently in plants using steel as a raw material, the necessity of careful classification and segregation based on chemical and metallurgical inspection, is not readily apparent. The writer has had occasion to note some results of using steel where ordinary precautions of handling were maintained, the stock being kept in bins according to size and type, without laboratory inspection as a guide to acceptance and classification. Investigations of this stock and of rejected parts made from it, disclosed numerous instances where stock of entirely wrong composition had crept into production, instances which should convey an important message to the "steel is steel" type of man, whether he be plant official, or ultimate consumer. Among the examples were:

Camshafts that were too hard to machine, were found to have carbon contents varying from 0.30 to 0.50 per cent.

Broken crankshafts, supposedly made from 1045 steel, actually contained 0.15 to 0.25 per cent carbon.

Axles that could not be heat treated successfully showed 0.30 per cent carbon instead of the 0.40 per cent required.

Gears, for which were specified steel of 0.40 to 0.50 per cent carbon and a minimum Brinell hardness of 418 after water quenching, showed hardness values of 241 to 321 instead, and ran but 0.30 per cent carbon.

Gears of the same specification, which cracked into several pieces on quenching, gave analysis of 0.57 to 0.62 per cent carbon, and 1.45 to 1.66 per cent manganese.

Similar gears, showed a Brinell hardness of 126 after quenching, and analyzed 0.07 per cent carbon, 0.39 per cent manganese.

Camshafts rejected because of soft spots after hardening, were found to have been made from steel with up to 0.070 per cent phosphorus content.

A bar to bar analysis of several heats of 1020 stock disclosed seventy bars of 0.30 to 0.45 per cent carbon, which otherwise would have been forged into about 400 camshafts and 600 gears, to be rejected at some point in process as unfit for use.

Such instances are representative of difficulties that may arise in the use of improperly segregated steel; but these are not all for the losses incurred in heat treating mixed stock may easily become serious, with accompanying lowering of production or quality. All of the stock may satisfactorily meet the composition requirements for a given type; but it may be shown that steels of practically identical composition do not necessarily respond in like manner to the same treatment. A typical ex-

A paper presented by title before a meeting of the Society. The author, C. F. Smart, was assistant metallurgist, Ingalls-Shepard Division, Wyman-Gordon Co., Harvey, Ill.

ample of this nature was found in the case of three heats of 1045 steel whose composition ranges as shown by analyses of samples from six bars of each heat were as follows:

Heat	Size	Carbon per cent	Manganese per cent	Phosphorus per cent	Sulphur per cent
A	3 inch round	0.41—0.45	0.54—0.78	0.035—0.042	0.025—0.042
B	3 inch square	0.40—0.44	0.55—0.60	0.020	0.034—0.038
C	2 5-7 inch square	0.42—0.46	0.63—0.69	0.24	0.044—0.048

Sections from bars of each heat were held for two hours at 1525 degrees Fahr., quenched in water, reheated to 1000 degrees Fahr. for two hours and cooled in air. The Brinell hardness values as determined

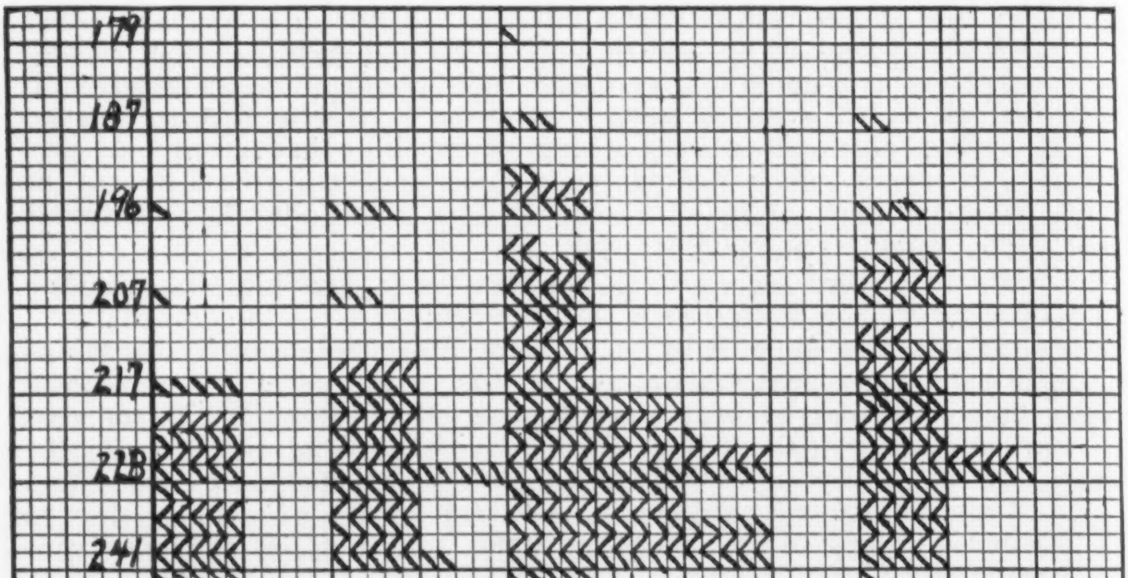

Fig. 1—Brinell hardness-drawing temperature chart. Number of tests falling in each class are indicated by number of diagonal lines appearing in small squares

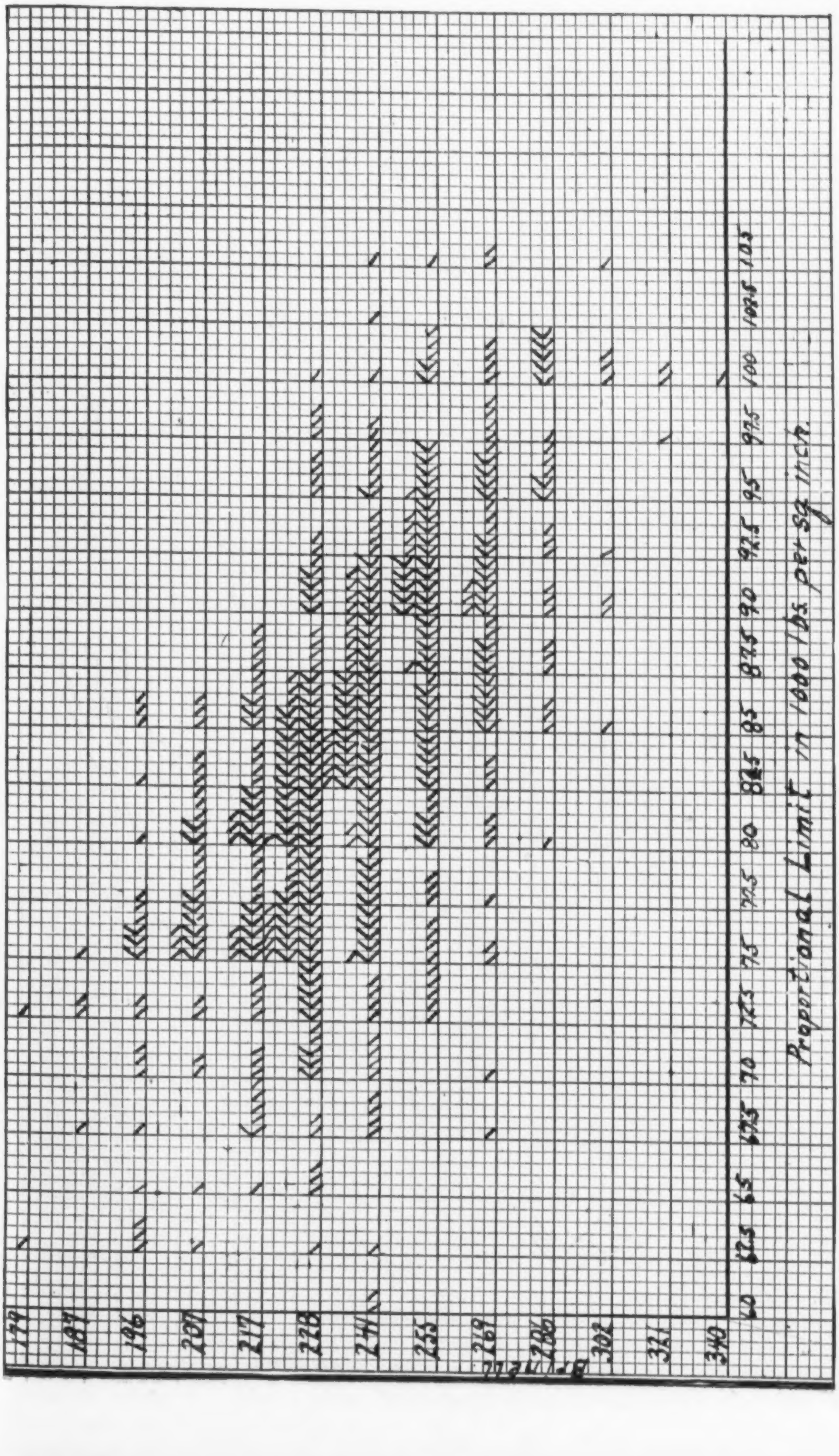

Fig. 2—Brinell hardness-proportional limit chart. Number of tests falling in each class are indicated by number of diagonal lines appearing in small squares

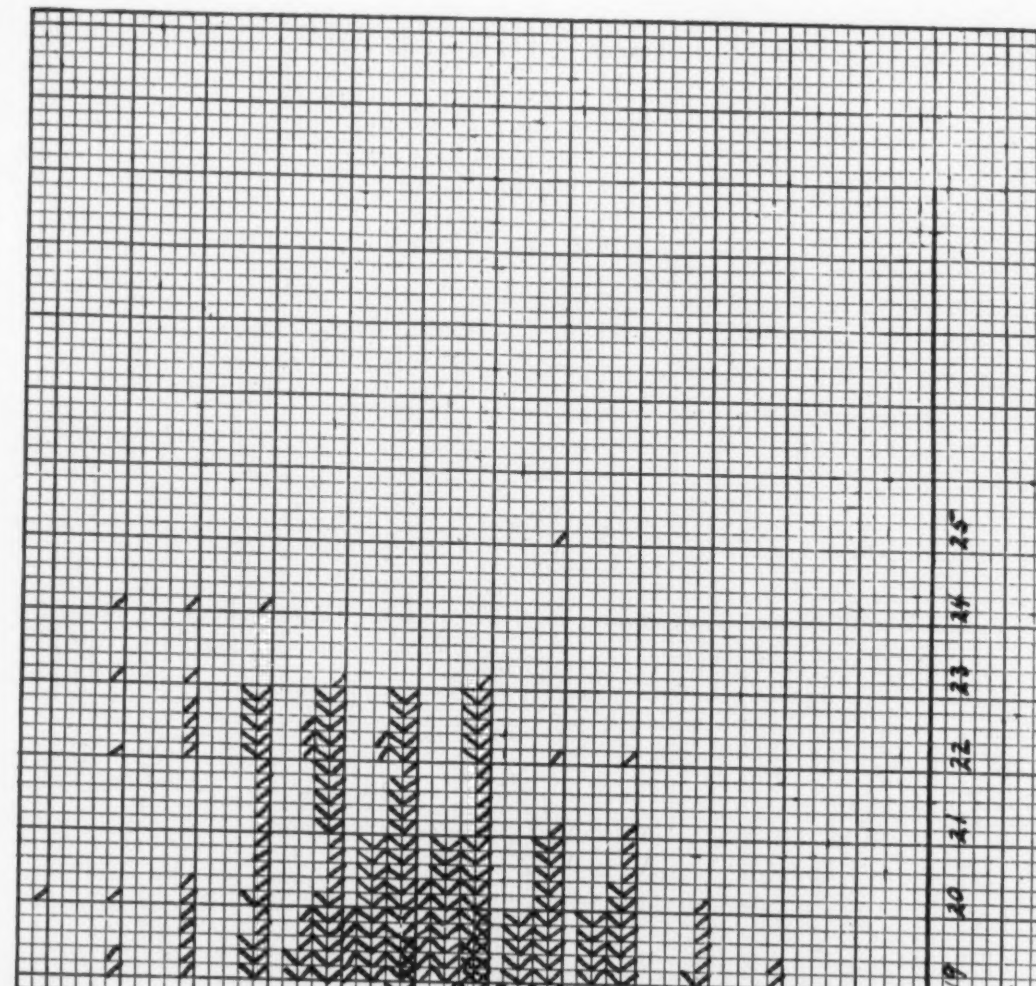

Fig. 3—Brinell hardness—Elongation chart. Number of tests falling in each class are indicated by number of diagonal lines appearing in small squares

TABLE I.

TEMPERATURE—BRINELL DATA

Temperature degrees Fahr.		Number of tests								
		Class 1		Class 2		Class 3		Class 4		All classes
950		12		13		24		95		144
975		52		..		24		14		90
1000		32		27		69		129		257
1050		7		14		22		86		129
	Totals	103		54		139		324		620
Tests Showing Less Than 217 Brinell										
Temperature degrees Fahr.	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
950	..	....	..	....	1	4.2	2	2.1	3	2.1
975	4	7.7	..	....	7	29.2	..	....	11	12.2
1000	4	12.5	3	11.1	16	23.2	15	11.6	38	14.8
1050	2	28.6	..	....	5	22.8	17	19.8	24	18.5
Tests Showing Over 255 Brinell										
950	9	75.0	10	77.0	8	33.3	34	35.8	61	42.4
975	1	1.9	..	....	4	16.6	8	57.0	13	14.3
1000	3	10.0	6	22.2	11	15.9	13	10.1	33	12.8
1050	1	14.3	1	7.2	1	4.5	8	9.3	11	8.5
Tests Showing 217 to 255 Brinell										
950	3	25.0	3	23.0	15	62.5	59	62.1	80	55.5
975	47	90.4	..	....	13	54.2	6	43.0	66	73.3
1000	25	78.0	18	66.6	42	60.9	101	78.4	186	72.5
1050	4	57.1	13	92.8	16	72.7	61	71.0	94	72.8

after the quench and draw were:

Heat	Brinell hardness after quench	Brinell hardness after draw
A	555—600	262—286
B	340—444	241—269
C	286—340	217—241

In heat treating crankshafts forged from these heats it was necessary to draw *A* at 1050 degrees Fahr., *B* at 1000 degrees Fahr. and *C* at 875 degrees Fahr., in order to meet the same hardness requirement of 217 to 255 Brinell.

The response to heat treatment of nine heats of hot-rolled, 3-inch square, 1045 steel, was followed metallographically. In condition as received, examined at 100 diameters magnification the grain size varied in appearance from four or five grains to the linear inch in the most refined heat, to grains an inch to 1½ inches diameter in the least refined heat. Full size sections were given a normalizing treatment. holding at a temperature of 1600 degrees Fahr. for three hour periods and sections examined after three hours, six hours and nine hours at heat. The steel with the finest initial grain was very well refined after three hours while the stock with the coarsest initial grain showed no indication of refinement after three hours, was partially refined after six hours and still not completely refined after nine hours treatment. Could uniform physical properties be expected following an ordinary quench and draw of a mixed lot of forgings from these heats?

A summary of over 600 tensile tests made on coupons forged from 1045 steel shows quite clearly some of the variation that may be encountered in heat treating mixed heats of the same type of steel. These coupons were forged to a section 2½ inches in diameter from bars varying in size up to 4 inches diameter. After forging they were heat treated under laboratory conditions in electric muffle furnaces subject to accurate pyrometer control. The tensile test specimens were taken midway be-

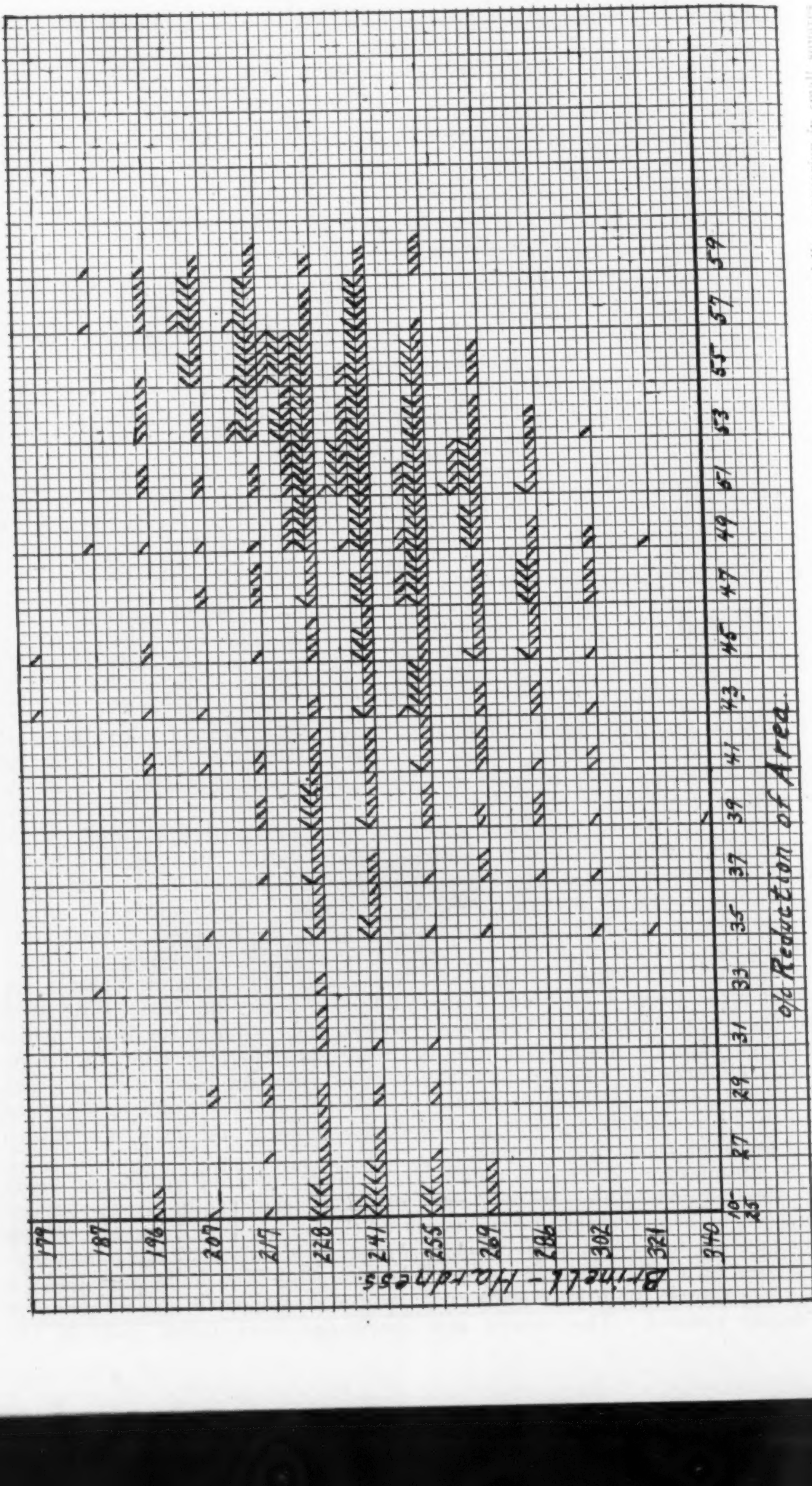

Fig. 4—Brinell hardness—Reduction of area chart. Number of tests falling in each class are indicated by number of diagonal lines appearing in small squares

tween center and surface of the coupons. Heat treatment consisted in a water quench from a temperature of 1525 degrees Fahr. and a draw at temperatures of 950, 975, 1000 and 1050 degrees Fahr.

The steels upon which these tests were made were all within the S. A. E. specification for 1045 steel: Carbon 0.40 to 0.50 per cent, manganese 0.50 to 0.80 per cent, phosphorus 0.045 per cent maximum and sulphur 0.050 per cent maximum. For the purpose of this summary they were divided into four classes as follows:

	Carbon percent	Manganese per cent
Class 1	0.40—0.45	Less than 0.60
" 2	0.45—0.50	" " "
" 3	0.40—0.45	Over " "
" 4	0.45—0.50	" " "

Division of the above was made in accordance with results of analyses of at least six bars of each heat. Lots with a composition range too wide for any single group were omitted from consideration. As so classified there were 17 heats in Class 7, 9 heats in Class 2, 24 heats in Class 3, and 55 heats in Class 4. Results have been tabulated by classes,

TABLE II.

BRINELL, PROPORTIONAL LIMIT, REDUCTION OF AREA AND ELONGATION DATA

	Class 1		Class 2		Class 3		Class 4		All classes	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Tests under 217 Brinell..	10	....	3	....	29	....	34	....	76	....
OK for proportional limit	8	80.0	..	....	22	76.0	32	94.0	62	81.5
OK for reduction of area	7	70.0	2	66.6	21	72.5	34	100	64	84.1
OK for elongation.......	9	90.0	1	33.3	25	86.2	31	91.2	66	86.8
Tests 217-255 Brinell....	79	....	34	....	86	....	227	....	426	....
OK for proportional limit	65	82.4	33	97.0	86	100	227	100	411	96.5
OK for reduction of area	34	43.0	15	43.1	60	69.8	172	75.7	281	66.0
OK for elongation......	49	62.0	32	94.0	74	86.0	200	88.0	355	83.3
Tests over 255 Brinell..	14	....	17	....	24	....	63	....	118	....
OK for proportional limit	14	100	17	100	21	87.5	63	100	115	97.5
OK for reduction of area	9	64.3	12	70.5	18	75.0	40	63.5	79	67.0
OK for elongation......	12	85.8	16	94.1	20	83.3	61	97.0	109	92.5
Total number of tests....	103	....	54	....	139	....	324	....	620	....
OK for proportional limit	87	84.4	50	92.5	129	92.8	322	99.3	588	94.8
OK for reduction of area	50	48.5	29	53.8	99	71.2	246	76.0	424	68.4
OK for elongation......	70	68.0	49	91.0	119	85.6	292	90.0	530	85.5
OK for Brinell.........	79	76.6	34	63.0	86	61.8	227	70.0	426	68.8

with drawing temperature, proportional limit, per cent elongation in 2 inches, and per cent reduction of area referred to Brinell hardness value, bearing in mind the specification for physical properties that the treated stock was required to meet, that is proportional limit 70,000 pounds per square inch, elongation in 2 inches 15 per cent minimum, reduction of area 45 per cent minimum, and Brinell hardness 217 to 255. Summaries of such tabulation are presented in Tables I and II.

The percentages calculated for Table I represent the ratio of the number of tests of one class drawn at a specified temperature and showing the given Brinell range, to the total number of tests of this class and draw temperature. The percentages of Table II represent the ratio of those tests of tensile property above the specified minimum, to the total in each class and Brinell range.

Examination of these tables gives some idea of the difficulty of obtaining a product of uniform properties in heat treating a mixture of stock of this nature. For 1045 steel as a type, the best practice obtained for any one drawing temperature was 73.3 per cent, based on the Brinell test, while for all temperatures the average practice was 68.8 per cent.

Figs. 1, 2, 3 and 4 have been plotted to show graphically the distribution of results as obtained on all classes combined. The Brinell value has been plotted against the values for temperature of draw, proportional limit, per cent elongation and per cent reduction of area. A section of the paper between two Brinell values and two values for the other property under consideration was taken as belonging to tests showing the values toward the left and bottom of the diagram. A mark has been made through one small square to represent each test. In plotting it was necessary to use wider ranges between units than those to which the actual readings were taken and for this reason there may be slight discrepancy between the numerical and the graphical data. It is believed, however, that this has in no way affected the value of the diagrams and that they are true pictures of the distribution of the values obtained. These figures show for 1045 steel:

That when quenched from a proper temperature and drawn at any of the temperatures used for these tests, the Brinell values may be distributed over a very wide range.

That for a specified minimum Brinell hardness of 217, more than 10 per cent of the values for proportional limit were below the specified minimum of 70,000 pounds per square inch.

That for a given Brinell hardness value, the values for proportional limit may vary widely. Thus at 228 Brinell, 90 per cent of the values for proportional limit are quite uniformly spread over a range of from 70,000 pounds per square inch to 90,000 pounds per square inch.

That the Brinell value cannot be accepted as definite assurance of what the values for elongation and reduction of area will be. At 228 Brinell, 17 per cent of the values for elongation are below the specified minimum of 15 per cent, at the same hardness value 35 per cent of the figures for reduction of area are below the specified minimum of 45 per cent.

That it would be impossible, treating this mixed stock, to turn out a highly uniform product from the heat treating plant, and at the same time to maintain a low percentage of rejection.

It is not within the scope of this paper to discuss the causes of such variation. It may be argued that good steel, properly forged, would show better results than these. Granting this point, how is the heat treater to distinguish the good steel from the bad, the well worked piece from the poorly worked? Can better practice and greater uniformity be maintained, if the heat treating force is required to accept mixed heats of a given type and left to guess at an average treatment?

A study of the tabulation of several hundred thousands of hardness determinations on heat treated stock leads to the belief that about 70 per cent practice is all that can be consistently obtained in the commercial treatment of carbon steel forgings from mixed heats, working to a Brinell range of 0.3 millimeters. The same is true for certain so-styled individual heats, in more than one of which a variation of carbon content of from 0.38 to 0.51 per cent has been found. On the other hand if steel be kept properly segregated according to individual heats, which have been checked with a sufficient number of analyses to assure uniformity, it is entirely possible by basing heat treatment on results of experiment and metallurgical tests, to maintain a practice of 99 per cent

(*Concluded on Page* 334)

DISCUSSIONS FOLLOWING PAPERS PRESENTED AT THE TUESDAY MORNING TECHNICAL SESSION OF THE ANNUAL CONVENTION, DETROIT, OCTOBER, 1922

THE first technical session held during the annual convention of the society in Detroit, Oct. 2-7 was called to order by the chairman, Prof. H. M. Boylston of Case School of Applied Science, at 10 a. m. Tuesday, Oct. 3.

H. B. Knowlton of the Vocational School of Milwaukee presented the first paper which was published in full in the September, 1922 issue of TRANSACTIONS.

After reading his paper as published, Mr. Knowlton added the following comments in concluding:

Mr. Knowlton: In conclusion we will say that successful carburizing requires a great deal of study, that we must use the strong carburizing materials wherever we may get them. We must be sure of their uniformity. If we make them ourselves, we must be very careful with our mixture. There must not be a great amount of chemical or strong carburizing agent of any kind in one part of the pot and not in another. We should take great care that pieces are not unduly close up to the top of the pot.

I might mention a commercial example of this that came to my attention a year or so ago, a firm was having trouble with soft spots in their work. They were making thrust ball bearings and were soft even after grinding. When we checked up on the grinding operation we found that the race side was ground first and a great deal more stock was taken off the opposite side than was taken off the ball race side. By grinding the under side, these races were hard where they had shown soft spots before. The decarburization was quite deep and by the aid of the microscope it was found that decarburization had occurred in the carburizing heat itself. On examining the plant conditions we found that they were using large boxes with nothing but a clay seal over the top. The boxes had been in use for a long while, and they were using a carburizing material containing salt, and there had been corrosion, until, in fact, there were holes in the sides of some of the boxes. These holes were plugged with clay and the top was covered with clay. They wanted to know why they got decarburization, and why they got soft spots on some of their work and not on other work. I will leave it to this test if it doesn't indicate that the probability was that toward he end of the carburizing heat, which was very long, 12 hours at 1700 degrees Fahr., there probably was a concentration of CO_2, which is decarburizing rather than CO, which is carburizing, near the places where the clay filled the holes and covered the tops of the pots. So that we should have well sealed pots as well. I thank you.

Chairman Boylston: We have listened to a very interesting paper by Mr. Knowlton. I believe that we cannot hear these points brought out too often, because there are so many variables in carburizing that one must keep all of them constantly in mind in the packing problem. If there are no questions or discussion on this paper we will pass on to the next paper, entitled *Case Hardening*, by A. H. d'Arcambal, metallurgist with the Pratt and Whitney Co., of Hartford, Conn.

Mr. d'Arcambal: Mr. Chairman and Gentlemen—When Mr. Dawe

asked me to prepare a paper for the convention this fall I started looking around for a subject that would create quite a bit of discussion. I do not think there are any two divisions of case hardening that would create more discussion than that of the chemical reactions taking place in the cyanide process of case hardening and impact tests on carburizing steels. There have been a large number of articles published recently on the value and significance of impact tests, etc., but on looking through the literature we can find no trace of where any work had ever been performed on the impact testing of carburizing steels either on samples in the carburized and hardened condition or on specimens treated by packing in sand instead of case hardening material, then double and single quenching. The first part of this paper deals with the chemical reactions taking place in the cyanide process of case hardening, the remainder of the paper giving the results of some Izod notched bar tests on several well known types of case hardening steels. Mr. d'Arcambal presented his paper as published in the September, 1922 issue of TRANSACTIONS.

Mr. d'Arcambal's Paper Corrected

Following the first sentence ending on the second line of page 1120 September, 1922 TRANSACTIONS the following sentence should have been inserted—Somewhat lower impact readings would have been obtained on the 6120 series if the carbon content had been the same as in the other alloy steels.

The sentence preceding the last paragraph of the paper should read—Not so much difference was noted in the fractures of the 6120 steel specimens after double and single quenching, only a slight coarsely grained structure being obtained on the specimens of this type of steel after single treating.

Chairman Boylston: I think you will all agree with me that Mr. d'Arcambal has added considerably to the available printed data, especially in regard to case hardened material, and especially has he added new information on the effect of nitrogen in the case hardening operation. In that last table I noticed that those specimens that Mr. d'Arcambal pointed out, which had a slightly greater hardness after single quenching, that is the second quench on the double quench specimens was about fifty degrees lower than in the single quench. Is it clear that the double quenched specimens had their case fully hardened? Might not that account for the slightly lower hardness?

Mr. d'Arcambal: I do not understand your question. You mean when you quench for case refinement only?

Chairman Boylston: Yes.

Mr. d'Arcambal: When carburized specimens are given only a single refining treatment a temperature slightly higher than is necessary to refine the case is usually used, so as to refine the core to a very small degree.

Chairman Boylston: Might it not be possible on the double quench that the second was a little too low to get the full hardening effect? That might be one way of accounting for the lower hardness in the double quenching.

Mr. d'Arcambal: You should obtain a greater hardening effect on the core on single quenching only, for you have used a higher tem-

perature than used for the case refining heat when double treating. We didn't attempt to refine the core to any great extent on the single quenched specimens, for that is not the usual practice.

Chairman Boylston: Are there any questions?

Mr. E. C. Brown: You mentioned that if you had not cooled your specimens in lime your results would have been higher. What reaction took place there in the lime?

Mr. d'Arcambal: It is our belief that if we had quenched the specimens, more of the nitrogen would have been retained in the combined form. This method we used gives only the iron nitride, and slow cooling seems to produce considerable free nitrogen. We did not treat the specimens after cooling in lime, for they were machinable.

Question: Did you pre-heat your test specimen before you immersed it in the cyanide?

Mr. d'Arcambal: No, we placed the specimens in the cyanide bath at somewhere around the desired temperature. As the samples cooled the bath slightly, a few minutes were required to bring the temperature back, the specimens were not actually at the temperature for the time specified. I might say that we found that the length of time in the cyanide did not affect the depth of case. We obtained around eight to ten thousandths case on all the samples but the time of immersion did affect the concentration of the carbon and the nitrogen.

Mr. Brown: I was just wondering why it wouldn't be a good idea to pre-heat all cyanide specimens.

Mr. d' Arcambal: As I stated, the time of immersion doesn't seem to make very much difference. The practice in one of the large plants I have recently visited is to immerse a large basket of work in the cyanide bath at around the desired temperature and of course the bath drops in temperature but as soon as the bath comes back to the required temperature they take the work out and quench it. Some lots might be left in the bath slightly longer than other lots. It depends on the rate of firing and also the amount of work you put in. They usually quench as soon as the bath reaches the temperature required, some parts being quenched in water and some in oil. I was surprised to note the hardness obtained on small parts quenched in oil. It was the opinion of a lot of people that you would have to quench cyanide pieces in water to obtain the proper hardness, but this company have obtained just as great a hardness oil quenching as water quenching.

Mr. Vanick: I was interested in the statement in the paper about the concentration of nitrogen. It seems to be misleading. That is, in the concentrated area, nitrogen appears as patches of pearlite. One might conclude from that that nitrogen in the form of these pearlite patches represents the most concentrated form of nitrogen compound. Now in the presence of carbon these patches are not a true iron nitrogen compound, but a compound of iron and carbon contaminated by nitrogen. We know pretty well, that in a high carbon steel, or a steel containing a progressive increase in carbon, that carbon will resist or impede the progress of nitrogen into the steel, and this resistance to penetration acts as a barrier which piles up the nitride or nitrogen in these higher carbon zones. This is borne out to some ex-

tent by Mr. d'Arcambal's results in which he shows an increase in carbon with an increase in nitrogen, and a very sharp decrease beyond that. But the main point I wish to bring out is that the nitride contained in the needle represents, as far as our experience has gone, a more concentrated form of iron nitride than that represented by the nitride patch or the pearlitic patch, and in fact, we have collected some circumstantial evidence; (It is not direct, on account of the very thin form of this nitride needle), that the needle type of nitride is a form of iron nitrite caught or trapped between the inter-cleavage or bedding planes, of the nitride needle), that the needle type of nitride is a form of iron nitride From that standpoint, if you consider the iron nitride needle as a very thin sliver of the compound of Fe_2N it is a more highly concentrated form of nitrogen than the pearlitic patch. Then, in making an analysis of this form of structure, of course we never do get the composition of the nitrogen compound when it is in the form of the nitride needles. That is, there is a great deal of surplus metal, which accompanies the sample, probably ferrite or whatever else is in the structure when we have used pure iron in the nitrogenization, of course the matrix is ferrite, which will bring down the total nitrogen to something like .05, or less, if the nitrogen is present in the needle form. But some structures which we have obtained on exposures to ammonia atmospheres have developed these thin nitride plates until they take on an appreciable width, and the entire width or the entire length of the grain is heavily filled with the compound of Fe_2N which stands all the way out, to the surface of the specimen.

Mr. d'Arcambal: May I ask if you attempted to harden the samples treated in ammonia gases, so as to see if you could obtain file hardness by nitrogenizing only.

Mr. Vanick: No, we haven't tried to investigate the hardening effect on these at all. The nitride is a very brittle substance, and any effort to test it with a file, I imagine, would either show very great hardness or it would scratch off much after the character of iron oxide or scale.

Mr. Bellis: There is one point I would like to bring out. I would like to ask Mr. d'Arcambal's opinion of the significance of the impact test in testing a routine test of carburized work. The reason I bring this up is because at Springfield Armory we found the results of the impact test rather misleading as a routine test. Possibly it was due entirely to the object we were carburizing. We were able to carburize a rifle receiver, and we consider that the high tensile strength, associated with a highly caburized case, added materially to the strength of the piece when it was subjected to an internal stress. I think it is generally considered that the case can add strength to a carburized piece. We found, though, that the carburized test pieces always gave very much lower readings of strength as indicated by foot pounds on impact than we found in actual practice. In other words, we would get twice as much strength in a carburized piece if we blew it up than we could in a piece that wasn't carburized. The impact test would show that piece to be only a small fraction as strong as the piece that had not been carburized. I would probably better state that again. In an actual performance test the receivers stood very much greater strength if they had been carburized. When it came to making an impact specimen from

the same piece, we found that the piece showed less strength after it was carburized. We attributed that to the fact that the nature of the impact test gave a brittle exterior and started a crack, and it was very easy to break the piece under a test of the nature of the impact test. I would like to have Mr. d'Arcambal give us his opinion on that point, as I think it may be misleading to take conclusions from impact tests as a test of efficiency of case hardening.

Mr. d'Arcambal: We have never used the impact test as a routine test for carburized work, but merely as a comparative test of different grades of steels given various treatments, as described in this paper. One would certainly expect greater strength on carburized and hardened parts made of alloy steel, than parts made of plain carbon steel, and the results obtained verified this. We also obtained higher impact readings on carburized specimens, double treated, as compared with single treated specimens, as would also be expected. While it is true that impact tests must be made on small specimens, one would expect that the material showing the highest resistance to shock in the form of these small specimens, would also show a correspondingly greater resistance to shock in larger sized specimens.

Mr. Bellis: We considered the rifle receiver as being a part subjected to excessive impact, and we were able to get 130,000 pounds pressure, as against 85,000 on a case hardened piece, greatly increasing the efficiency of the piece. Your sand treated pieces give greater strength than the carburized pieces. That might lead to the general conclusion that you cannot get strength in a carburized part.

Mr. d'Arcambal: We certainly would not expect material surrounded by a glass hard envelope to be as resistant to shock, as fairly ductile material not possessing a hard, brittle case. A small crack once started, would soon cause failure of the material. The impact test results obtained proved this belief in a very satisfactory manner. Tests on sand treated specimens were conducted merely to show the effect of the carburizing temperature and time on the different carburizing steels, double and single treated after the same treatment.

Mr. Bellis: Do I understand you consider the order of magnitude of the strength of the soft pieces and the case hardened pieces as given in the figures?

Mr. d'Arcambal: There was not so much difference shown in the alloy steels as in the plain carbon steels. Of course we expected that the plain carbon steels carburized and hardened would show higher impact values than were obtained but the carbon steel cases were considerably more brittle apparently than the alloy steel cases, thus giving very low impact readings.

Mr. Patterson: I would like to ask Mr. d'Arcambal if we are not overlooking some of the limitations of the impact method of testing? We know it is very important to have the given weight and specimens of a given size. If you use a different size specimen with the same pendulum, we get a result which we might possibly reduce to the standard size by making certain corrections. Now in service on a rifle part that was blown up by pressure, you will have of course a larger sized section than was used in the impact specimen, and the pressure necessary to blow it up. Tests of that kind, then, would be

equivalent to using a pendulum of a sufficient weight to break the specimen instead of using a pendulum of a constant weight, and in determining your residual swing of pendulum. If we make our investigations with different weight specimens or different sized specimens and different weight pendulums, we might get still more information from the impact testing.

Mr. d'Arcambal: Don't you believe, however, that the impact test is only a comparative test anyway? On the different steels we always use the same size specimens, the same striking distance, same pendulum etc., that is, everything is standardized. If a very tough steel was needed for an important part and we ran Izod impact tests on different steels and found, as in this case, that chrome vanadium steel showed the greatest resistance to shock and possessed the necessary tensile strength, etc., I certainly would feel it was the proper material to use regardless of the size of the part.

Mr. Patterson: If we would use different sized specimens and different weights of pendulum for a carbon steel and say determine the curve representing the corrections to be made from the size of specimen, and weight of pendulum, and then do the same thing with the chrome vanadium steel or some other steel, we might possibly get quite a different curve.

Mr. d'Arcambal: You would be nearer actual working conditions.

Mr. Patterson: If we got a very different curve for one steel than for the other, then it woudn't be fair to use the same size specimen for all steels and say "This steel is poorer than that," because maybe in the size used in service the correction curve would show that this poor steel in the small sized specimen may be a little better steel than a large sized specimen.

Mr. d'Arcambal: That point is very well taken. It is a very interesting proposition but when you come right down to it, the same thing might apply to a tensile test, for we usually pull the standard type tensile test specimen. It would be very interesting to obtain the different impact curves, because very little has been done on impact testing and what has been done has been very severely criticised. If some of the critics would do more actual practical work, I think we would obtain more information. I know that during the war in one of the airplane motor factories we found the impact value of very great importance on such parts as crankshafts and connecting rods. We were using S. A. E. 3140 steel on those parts. Of course the maximum Izod reading limit allowable took care of itself, because you had to meet a certain tensile strength and elastic limit, together with an 18 per cent minimum elongation and about a 50 per cent reduction of area. In one case a plane flying over Trenton crashed to earch because of the crankshaft breaking, killing the aviator. Since the plane contained our motor, the shaft was sent to us for examination. From four different places on the shaft we cut out tensile and impact specimens, and in every case the tensile specimens showed quite a bit higher results than the required limits, but the Izod values ran only 18 to 20 foot pounds, the minimum limit being 42 foot pounds. This was one of the first shafts turned out by the company and we could not find the original physical test report on the same. This shaft should of course have been rejected because of its low impact reading. I have heard there have also been many other cases where the tensile prop-

erties came well within the limits, but the Izod readings show so far below the minimum limit, with a coarse-grained structure, whereas on the tensile, a fine grained fracture was obtained. I personally have a lot of faith in Izod tests, or any other type of impact tests, although there really hasn't been much work done on this subject to date, especially on case hardening steels. The principal purpose of writing this paper on impact testing was not to obtain conclusive evidence as to the steels showing the highest resistance to shock because as stated in the paper, we were unable to make a direct comparison between the different steels, because the carbon varied four points from the lowest to the highest, but to learn the effect of single and double quenching on the Izod value, as well as to note the effect of pot quenching, etc. The brittleness produced by carbon being on the high side of the specification was also shown in these tests. As stated in the conclusion of this paper, it is hoped that the publication will result in the publication of more articles along similar lines.

Mr. Patterson: Where maximum impact value is desired, the use of lower carbon steel will give the best results. In every case where case hardened material is used, it is sometimes an advantage to have a little more rigidity or strength in the core. That is often the case on gears, truck gears, for instance, where the unit pressures are very high, and I know a number of truck people making gears who have a minimum hardness on the core so as to back up the case to withstand the high pressures.

I noticed in a comparison of the different steels that the nickel steels, the chrome nickel steels, the core had a considerably higher hardness than on the vanadium steels. I was wondering if Mr. d'Arcambal had run any impact tests in which the hardness of these steels had been the same.

Mr. d'Arcambal: Unfortunately, bath bars of S. A. E. 6120 steel showed the same low carbon content, and time did not allow us to obtain a new bar of this grade of steel.

Mr. Wickenden: The higher hardness you get, of course, the lower the impact value, and I should think that a comparison of the different rates could only be given after making an actual test, but in order to make a fair comparison of the impact values I should think it would be better to have the hardness of the core a little more even. This might be obtained by using a little lower temperature on the second quench on some of these steels. I know a number of people who for oil hardening 3.5 per cent nickel are using around 1350 or 1360 degrees Fahr. and in cases of water hardening they are going down to 1325 degrees Fahr. I think these lower temperatures would probably result in a slightly softer core, as it appears to me perhaps we are getting up just into the hardening range of the core. You will notice that in one case here, 1350 degrees Fahr. quench, on the second quench you have a hardness of 302, while at 1400 degrees Fahr. you get 370, and at 1370 degrees Fahr. you get 340. There is a gradual rise in hardness as you increase the temperature.

Mr. d'Arcambal: There is one thing interesting in regard to this discussion. On the S. A. E. 6120 steel marked *M,* we obtained a core brinell hardness of 255 to 265. On the S. A. E. 6120 marked *C,* a brinell reading of 295 was obtained without lowering the impact value as

compared with the *M* steel. The 295 brinell is not far removed from some of the brinell values received on the alloy steels, and in the case of the S. A. E. 3115 steel marked *E* in the carburized, pot cooled, and double quench condition exactly the same brinell reading was obtained but showed only 4 foot pounds Izod as against 11 foot pounds on the chrome vanadium marked S. A. E. 6120 *C*. In other words, we have a direct comparison of the impact value on two different steels with the same hardness, but with different carbon contents the S. A. E. 6120 showing much higher impact reading than the chrome nickel steel. These brinells, of course, were more or less difficult to obtain, as the specimens were only .450 inches in diameter, and we had to be careful to keep away from the carburized area.

Chairman Boylston: It seems too bad to interfere with an interesting discussion of this sort, but we have only fifteen minutes left of the session period and there is still another paper to be heard. We are certainly very grateful to Mr. d'Arcambal for this paper. Of course it is always within your province to write discussions later.

We will now have Mr. Ehn's paper on "Irregularities in Case Hardened Work Caused by Improperly Made Steel."

Mr. Ehn read his paper as published in the September, 1922 issue of TRANSACTIONS illustrating it by means of the stereopticon.

Chairman Boylston: We surely have chosen three very good authors this morning. Now is there any discussion on this extremely interesting paper?

Mr. Curran: My discussion on this tends to corroborate the results that Mr. Ehn has gotten in his work.

In the course of our examination of case hardened parts, and of tool steels in both the annealed and hardened conditions, we have often found it necessary to rely on the microscope to inform us as to the carbon content of the various zones in the case hardened specimens, or of the entire piece, where tool steels were under examination. In order to estimate closely the percentage of carbon present, it is essential that the structure of the specimen consist of lamellar pearlite plus grains of ferrite or networks of cementite, as the case might be.

We have observed that annealing at 1650 degrees Fahr. (i. e. heating to and cooling slowly from that temperature) serves to produce the necessary pearlitic structure with well formed grains or networks of excess ferrite or cementite, depending on whether the steel is below or above .90 per cent in carbon content. With such structures the carbon content can be estimated sufficiently accurately to aid in the interpretation of the structures observed in the original specimen, previous to annealing.

From time to time, however, we have observed structures after such annealing, in which the cementite networks were irregular and in which th lamellae of the pearlite grains were widely separated. These occasional departures from the usual type structures did not cause serious difficulty, and were usually ascribed to slight variations in annealing temperature or in rate of cooling, and were dismissed as unimportant. In the light of Mr. Ehn's disclosures, however, these occasional imperfect structures acquired a new meaning, which demanded closer investigation.

We therefore selected from our photo micrograph files samples of

tool steels which showed banded structures such as are usually ascribed to segregation of phosphorus or dissolved oxides, or which we had reason to believe to be of poor quality otherwise. These specimens we annealed at 1650 degrees Fahr. and in many cases we observed that previously banded material now showed two structures similar to those

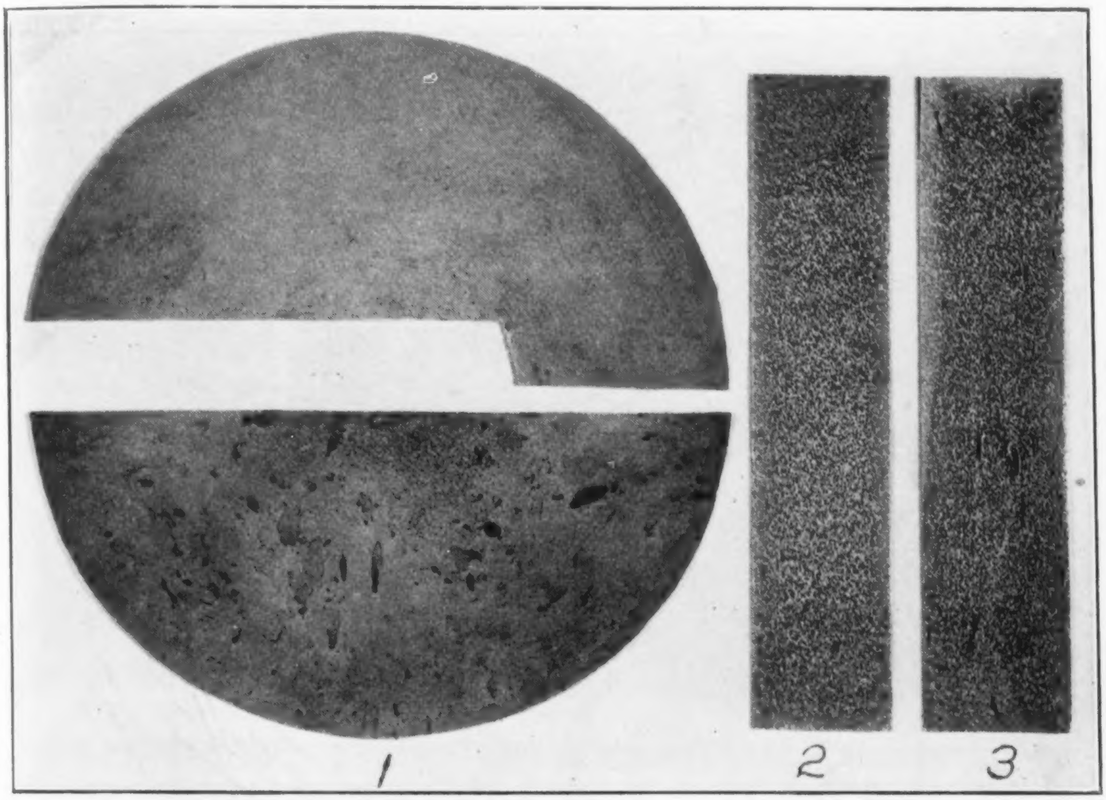

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Fig. 1—Showing the Effect of Macro-Etching a Transverse Section of a 6-inch Round Bar of Tool Steel—Carbon Content .90-1.00 Per Cent. The Upper Half, Machined But Not Etched, Appears Perfectly Sound. The Lower Half, After Etching in Hot Concentrated Acids, Shows Numerous Deeply Pitted Areas, Indicating Serious Segregation. Fig. 2—Macrostructure of Open Hearth Tool Steel Identified as "Good." Fig. 3—Macrostructure of Open Hearth Tool Steel Identified as "Bad." Upon Quenching These Two Specimens Under the Same Conditions the "Good" Specimen Hardened to a Depth of Three Times that of the "Bad" Specimen. × 2.

described by Mr. Ehn as "Normal" and "Abnormal." In some cases the entire specimen showed an abnormal structure. Two lots of steel which we knew to be irregular showed striking similarity to the abnormal structure after the annealing treatment. These will accordingly be shown in the following figures.

Fig. 1 shows the effect of macro-etching on a transverse section of a 6-inch round bar of tool steel, in which the carbon content was in the range .90-1.00 per cent. The upper half, machined but not etched, appears perfectly sound. The lower half, after etching in hot concentrated acids, shows numerous deeply pitted areas, indicating serious segregation. Figs 4 and 5 show the structures observed in the bar as received, at a magnification of 500 diameters. These structures consist of lamellar pearlite and of spheroidal cementite and ferrite, respectively, and occur in adjoining bands in the same specimen. These structures are somewhat similar to the normal and abnormal structures described by Mr. Ehn. On annealing a section of this bar at 1650 de-

grees Fahr. the structures shown in Figs. 6 and 7 result. These occur in parallel adjoining bands as before, and consist of finely lamellar pearlite and coarsely lamellar pearlite, respectively. We believe that the wider separation of the lamellae in the areas represented by Fig. 7 is an indication of the presence of some abnormal condition, possibly, as suggested by Mr. Ehn, it indicates the presence of dissolved oxides.

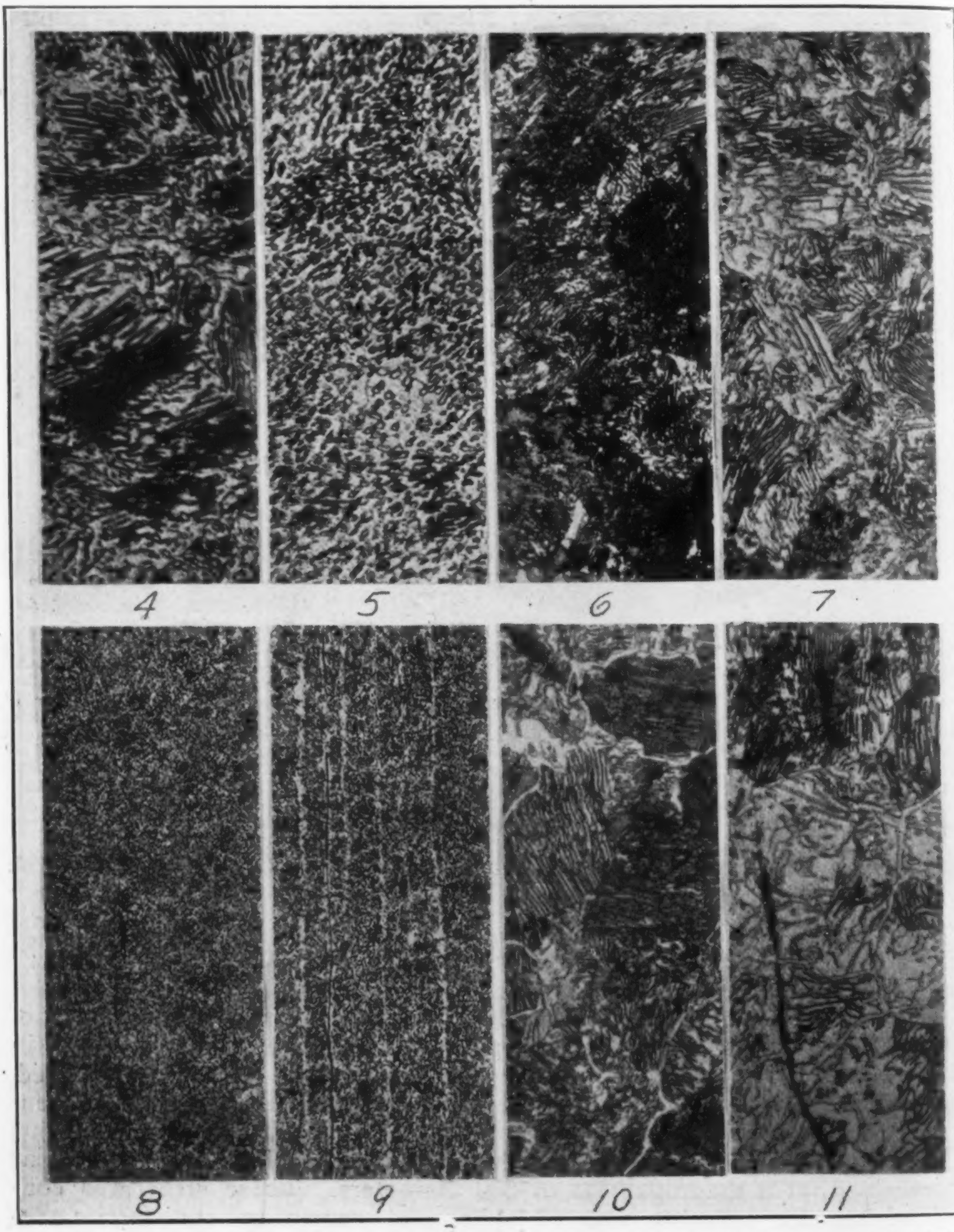


Fig. 4—Six-Inch Round Tool Steel as Received × 500. Fig. 5—Similar to Fig. 4. Carbon Content .90-1.00 Per Cent × 500. Figs. 6 and 7 Show the Results Obtained After Annealing at 1650 Degrees Fahr. × 500. Figs. 8 and 9 Show an Open Hearth Tool Steel of Different Heats. Carbon Content 1.10 Per Cent. Manganese .35 Per Cent × 100. Figs. 10 and 11 Show the Same Specimens After Annealing at 1650 Degrees Fahr. × 500.

A second example of abnormal structure is shown in Figs. 2, 3, 8 to 11 inclusive. These were taken from an investigation which we made of several samples of open hearth tool steel from different heats. These samples were classed as "Good" and "Bad" respectively, and our investigation indicated that the good sample was better than the bad in several ways. First, the macrostructure of the good sample, Fig. 2 as revealed by the macro-etch was better than that of the bad sample, Fig. 3. Second, on quenching specimens from both samples under the same conditions, the good sample hardened in for a depth three times that of the bad sample. Third, in the as-received condition, the microstructure of the good sample was free from the carbonless bands which were observed in the bad sample. These bands are usually ascribed to the presence of segregations of phosphorus or of dissolved oxides. Both specimens were perfectly spheroidized. Their structures, at 100 diameters, are shown in Figs. 8 and 9.

On annealing these two samples at 1650 degrees Fahr. Figs 10 and 11, the structures obtained exhibited marked differences. The good sample consisted of finely lamellar pearlite with well defined networks of excess cementite, whereas the bad sample consisted of coarsely lamellar pearlite with irregular, poorly defined cementite networks. This latter structure corresponds closely with those described by Mr. Ehn as "abnormal."

In the tests we have run on tool steels, we have used a simple anneal rather than a carburizing treatment. It seems probable that even better results might be obtained by actually carburizing the specimens. The differences in structure would probably be even more pronounced than those which we have obtained.

We believe that Mr. Ehn's carburizing test will prove a valuable aid in solving many of the difficulties which we encounter from time to time, and which in the past, after exhausting all ordinary means of investigation, we have been forced to ascribe to some obscure cause intimately related to the melting, refining, and pouring of the steel. Thus far it corroborates the results of the macro-etch, which until now has been probably our most instructive single test.

Mr. d'Arcambal: I would like to ask Mr. Ehn what experience he has found with Bessemer Screw stock. We know that such material contains considerable free and dissolved oxides. Our experience has been that we have always been able to obtain a well defined network after carburizing.

Mr. Ehn: My experience with bessemer screw stock is that usually the carburized structure shows exactly the condition you speak of, a large grain size, and at the same time a very pronounced disintergration of the pearlite. I consider some of the samples of this kind that I have seen as about the worst possible.

Mr. d'Arcambal: I was wondering if the fact that you had the network structure and disintegrated pearlite would cause you to have soft spots.

Mr. Ehn: I am pretty sure it will.

Mr. d'Arcambal: Screw stock is used extensively for carburizing and gives trouble at times, the same as S. A. E. 1015 steels, etc.

Mr. Ehn: I would say the reason probably is that some screw stock is bad, and some is not so bad.

Mr. d'Arcambal: There is another point about which I corresponded with you recently. On the S. A. E. 6120 steels we were unable to produce a network of cementite, although we could produce a cementite network on S. A. E. 5120 steels. Your paper I believe deals mostly with plain carbon steel.

Mr. Ehn: Yes, only with plain carbon steel. My experience has been that with say about one-half of one per cent of chromium or a little vanadium it is almost impossible to produce these real bad structures, so on the strength of our experiments we have changed our specifications for carburizing steel. Our specifications now call for from .30 to .50 chromium, and you kwow, most of you, that S. A. E. 1015 or 1020 often give trouble in the machining on account of the steel being too soft. The chromium makes it a little harder and makes it a little more free cutting, and I am also sure it helps so far as the carburizing and hardening is concerned.

Mr. d'Arcambal: Do you obtain a normal structure with that material?

Mr. Ehn: Yes, but it should be pointed out that there is no absolute certainty that a small percentage of chrome will always produce a good steel, if the furnace conditions are bad, but I believe it will help considerably.

Mr. d'Arcambal: We have had a hard time to find any chrome-vanadium steel that shows what you call a normal structure.

Mr. Ehn: Here is the point. A normal structure the way that I have described it here, will have to be confined to S. A. E. 1020 steel and with a different analysis, it is necessary to have other standards for abnormality and normality, however, I believe that they will be mainly along the same lines.

Mr. d'Arcambal: We sincerely hope that you will conduct experiments later on to show what is a normal and abnormal structure for alloy steels; because if you can develop such structures the same way you have developed the plain carbon steel. it will add greatly to the value of your important paper.

Mr. Ehn: I would say in answer to a previous speaker, that it is now a pretty well accepted view that ghostliness and banded structures are due to oxides in solid solution in the steel.

The carburized structure of a ghostline is exactly the same as that of a very abnormal steel. I think it is only reasonable to assume that if the abnormal structure in a ghostline is caused by oxides, that a uniformaly abnormal structure in steel is due also to oxides in solid solution.

A Member: Mr. Ehn is right when he says that oxides are now generally conceded as the reason for ghostlines, and his conclusions in regard to his abnormal steels are reasonable.

Mr. d'Arcambal: I would like to ask Mr. Ehn about the spring steel,—did you pack that in carburizing material?

Mr. Ehn: Yes, and we got just the structures and I showed you. The abnormal structures in regard to grain size can be brought out without carburizing, but even with low carbon material the effect is exaggerated by the higher carbon content at the surface, and with a high carbon tool steel I am pretty sure that, at least in the spring steels we have tested, we would not have been able to get any results without

carburizing. We have tested at least 15 or 20 of these spring steels by carburizing and our results checked very well with the results obtained in heat treating of these different steels.

Mr. d'Arcambal: Most of our tool steels run from 1.10 to 1.25 carbon.

Mr. Ehn: I don't know, I have had no great experience with steels of this analysis, but I am sure that the carburizing gases will have a tendency to bring out the normal or abnormal structures more clearly than if there is no such gases present.

Mr. d'Arcambal: Did you make chemical determinations for the oxides and nitrides in the good steels as compared with the poor steels?

Mr. Ehn: We tried to do that, but the results obtained were not very satisfactory. I showed for instance, a photograph here of two steels, one deozidized with ferro-manganese and the other deozidized with aluminum. In the case of aluminum as a deoxidizer the oxygen is probably contained as aluminum oxide, and there is hardly any way possible by which the oxygen content in that steel could be determined chemically, so chemical determinations of oxygen can hardly be of much value in this connection.

Mr. Styri: Were the structures obtained after quenching?

Mr. Ehn: The structures that I showed were not from quenched specimens. After quenching you can hardly see any difference at all. These structures are the structures after carburizing, and before quenching.

Mr. Styri: What is the effect of the temperature of carburizing on the oxides?

Mr. Ehn: I showed four pictures of abnormal steel carburized at different temperatures, the first showing a carburizing temperature of about 1700 degrees Fahr. In that case both the case and the core showed a fine grain. In raising the temperature the fine grain persisted up to about 1900 degrees Fahr. in the hypereutectoid zone close to the surface of the specimens, but farther in the grain starts to grow. At a still higher temperature, about 2000 degrees Fahr. and above, the grain grows, both in the area near the surface and farther in toward the core. At a still higher temperature of about 2200 degrees Fahr. the structure at the surface invariably consists of pearlite with cementite needles. Just exactly why that is I don't know, but it is a fact.

Mr. Styri: I meant between the normal and the abnormal steel.

Mr. Ehn: The normal steel shows already at 1700 degrees Fahr. a normal structure, and with a raised temperature there is no change except at very high temperature, when a needle structure is obtained. The change in structure occurs only in the abnormal steel, and with the steels used for this test there was no difference in the structure at 2000 degrees Fahr. between abnormal and the normal test pieces.

Mr. d'Arcambal: Do the steel mills object very strenuously to rejections because of abnormal structures?

Mr. Ehn: They did to start with, but we had an experience that convinced them. One steel mill sent us four or five heats and told us to pick out the bad ones. We picked out two, and they found out they were what they called *off heats* made during a night shift, and after that they did not kick about it.

Mr. Knowlton: On steel deoxidized with aluminum and low carbon

steel which is not to be case hardened, there has recently been an argument on electric steel, showing up a considerable amount of non-metallic impurities, carbon, from .22 to .28 per cent. One of the deoxidizers was aluminum. After repeated annealings some of these show, of course, not band impurities, but an alkaline network of original grains showing up white. Would that be due to deoxidization?

Mr. Ehn: I wouldn't like to off hand, to give an opinion.

Mr. Alvan Davis: I think I might say regarding the question of aluminum, aluminum I guess is universally used. Comparatively no steel is made without it. The difficulties you may experience I think would not necessarily be due to the use of aluminum. Of course it can be used in excessive amounts. The trouble I believe usually is due to excessive temperature.

Mr. Hildorf: I thought it might be interesting to know the application of this method of checking steel in an auto plant. We have had it in use new for nearly a year, and I guess anyone that has had anything to do with autos, or S. A. E. 1015 or 1020 steels occasionally get soft spots, but we haven't had it for months. On no parts have we failed to get away from soft spots, and that means 100 per cent on our stuff so far. We don't know how long it is going to last. We have gone now, I believe I am safe in saying, eight or nine months without a soft camshaft. That is, due to soft spots. We have had slips, of course, but that doesn't mean that it is caused by soft spots. Of course that doesn't mean they can get off on temperature out in the hardening room and we won't get them soft. But if they are soft it is usually half of the camshaft, or the whole shaft. And the same thing holds true with the other parts. Our check consists of taking samples at the same time that we take samples for chemical analysis. These samples are sent to the heat treating department and carburized at 1700 degrees Fahr. That is standard for our plant. These samples are then cooled in the box and a corner or section is cut out, with a saw, polished, and examined under the microscope. By that time, of course, chemical analyses will be run, and we decide at that time as to whether we will use the steel. Of course when one starts in with that, there will be more rejections for microstructure than there will be from analysis. It is very common to find analyses that nearly hit the center of our limits and still be very, very bad or very, very different, I might say, as to their microstructure.

As to tool steels, we haven't tried, as one of the speakers here mentioned, annealing. That is going into it very extensively, and didn't seem to get results, so we have been testing the tool steels in exactly the same way as we tested the S. A. E. 1015, by carburizing, and we find that it will work on steels of even 1.25 per cent carbon.

Chairman Boylston: Is there any further discussion or anything further any member would like to add? If not, we will declare this session adjourned.

DISCUSSIONS FOLLOWING PAPERS PRESENTED AT THE WEDNESDAY MORNING TECHNICAL SESSION OF THE ANNUAL CONVENTION, DETROIT, OCTOBER, 1922

THE second technical session held during the annual convention of the society in Detroit, Oct. 2-7 was called to order by the chairman, J. Fletcher Harper, research engineer with the Allis Chalmers Mfg. Co., West Allis, Wis., at 10 a. m. Wednesday, Oct. 4.

Mr. R. B. Schenck, metallurgist, with the Buick Motor Car Co., Flint, Mich., presented his paper entitled "Heat Treating in Lead." Mr. Schenck's paper was published in the September, 1922 issue of TRANSACTIONS.

In reading his paper Mr. Schenck commented as follows:

Of course, we all know what happens when material containing moisture is put into a lead pot or any kind of a molten bath.

In connection with that statement it should be borne in mind that what is meant is direct heating by resistance, using electrodes and not the induced current effect as in the Ajax Northrup Furnace.

Chairman Harper: I am sure there must be some discussion of this paper. We have a short time to take up that discussion.

Discussion of Mr. Schenck's Paper

Mr. McCleary: I think Mr. Schenck's statement was that in drawing the axle shafts at about 800 degrees Fahr. he used a caustic soda bath at about 700 degrees Fahr. I wondered if there was a chemical reaction that prohibited the use of the caustic soda on the top of the lead bath itself, thereby shortening the number of operations necessary.

Mr. Schenck: Mr. McCleary, we have tried caustic soda on the top of the lead. It looked good at first. We ran for three or four days that way and then oxidation took place. It gradually loaded up with oxide until we had the worst kind of a mess you ever saw. But using the straight caustic soda we, of course, had no such trouble. That was the thing that we worked out ultimately on that job. The caustic soda covering doesn't seem to be successful. The temperature of the caustic soda bath is held just below the temperature of drawing, the temperature of drawing being 800 degrees Fahr. and the temperature of the caustic soda 775 degrees Fahr.

Mr. McCleary: That is what I meant, if it could be used directly on top and get away from the double operation.

Mr. Schenck: That is a very natural suggestion, and we did try it, but it was't successful for that reason.

Mr. Patterson: I want to ask Mr. Schenck what kind of a pot he used for the caustic soda. Would a chrome alloy pot stand up?

Mr. Schenck: We use a steel pot. An alloy pot is not necessary. If you used a nickel chrome alloy at those low temperatures, you certainly wouldn't get your money out of it. The steel stands up so satisfactorily, providing there is no excessive overheating at any time, that it is the most economical proposition. The fact is a steel pot will last for six months or longer on that job.

Mr. d'Arcambal: Do you find that the alloy pots, like nichrome, etc., are more economical in heat hours than the cast steel pots or semisteel pots?

Mr. Schenck: In our experience we find on some jobs that the high priced alloy pots are more economical. On some jobs they are not. A good cast steel pot, if the temperature is down around 1450 or 1500 degrees Fahr. does for a number of jobs give the most economical service. On the other hand, when the temperature runs higher, and in cases where the output is very large and requires extremely severe firing, the reverse is true. It is a proposition in connection with which it is very hard to make a definite statement. Conditions vary so that what is true in one plant will not necessarily be true in another plant.

Mr. d'Arcambal: With cast steel pots running around .50 carbon (ordinary steel castings) we are obtaining an average of nine months, running at a temperature varying from 1400 to 1500 degrees Fahr. six days a week, and it seems to me that to obtain a comparatively efficient life with nichrome or any similar alloy we would have to run four or five years. We find that is not the case. We cannot get that much service.

Mr. Schenck: You certainly could not. If you are getting anything like that service out of a steel pot, you want to stick to steel.

Mr. d'Arcambal: One other question. Do you use the same temperature when you are treating shafts, etc., heating them in a lead bath, as you do if you were heating in a muffle furnace?

Mr. Schenck: Yes, we do. The fact is that at one time we used a semi-muffle underfired furnace. We switched from the furnace to the lead without any change of temperature whatsoever in the quench. When it comes to the draw, in some cases that is a different matter. Take continuous drawing furnaces. I have seen them with the temperature conditions such that in changing to lead you would have to change the temperature. But we have not had that experience, except with continuous furnaces. We have found we could switch indiscriminately from oven furnaces to lead.

Mr. d'Arcambal: We have always found in hardening tools of 1.15 to 1.25 carbon it is necessary to use a slightly higher heating temperature when we heat them in a lead bath than when the muffle furnace is used. The only way I can account for that is that the rapid heating might in some way raise your Ac points, and it is necessary to go to a slightly higher temperature. For example, we can harden a tool from 1390 degrees Fahr. in a semi-muffle type furnace, quenching in a brine, very satisfactorily, but you have a hard time getting that hardness if you heat it in a lead bath. I wondered if you experienced the same difficulty.

Mr. Schenck: I can't say we have. Our experience with tool hardening in lead hasn't been so extensive. While there is the possibility that it exists in tool steel, we have not encountered it in other steels.

Mr. d'Arcambal: Of course, you have slightly wider range in alloy steels.

Mr. Schenck: Was the time of heating the same in both cases?

Mr. d'Arcambal: Take for example a one inch tap. About three minutes in a lead bath is sufficient at a temperature of 1440 to 1450 degrees Fahr. whereas it will take 12 to 15 minutes in the muffle furnace.

Mr. Schenck: Do you suppose if you left the tap in the lead bath 12 to 15 minutes you would get the same hardness?

Mr. d'Arcambal: You would obtain the hardness, but you would

get a coarsening of the grain. Lead has such a high heat conductivity that it would be practically the same as soaking in a muffle furnace for 10 minutes or longer.

Mr. Schenck: In connection with transmission gears, we find that the gears require a longer time than three or four minutes in lead. The gears are made of S. A. E. 3145 steel. We find we have to hold them at least 15 minutes to get minimum distortion, and we also get 2 or 3 points higher in scleroscope hardness if we hold 15 minutes instead of only 3 or 4.

Mr. d'Arcambal: Of course, in that case you have alloys that you want to get in solution. With your S. A. E. 3145 steels do you quench from the draw in oil to get away from notch brittleness

Mr. Schenck: No, we haven't been donig that. We have never found it necessary. The draw is low 400 to 450 degrees Fahr. and the finished hardness is 70 to 80 scleroscope. We do quench, but not particularly to get away from brittleness; S. A. E. 3145 axle shafts and S. A. E. 1045 are all quenched from the draw, but it is more a cleaning proposition than it is a question of notch brittleness. At the same time, though, we feel that we are killing two birds with one stone

Mr. d'Arcambal: We have found practically the same as you have, that nothing can beat charcoal for covering a lead bath to prevent oxidation of the lead. We have tried all the different salt mixtures, but we obtain a much cleaner tool by having a charcoal covering on the lead than by any other method.

Mr. Schenck: That is our experience.

Mr. Curran: One gentleman has asked about the pots used with your caustic soda. I wonder if he isn't worrying about something we ran across sometime ago. In using nickel and nickel alloy crucibles for melting sodium and potassium carbonate mixtures, we found what the nickel alloys corroded very rapidly. They ate right through. Usually the corrosion was the most rapid at the surface, at the air line, the surface of the liquid. Of course, your caustic soda would change over in rather a short time to carbonate. I wonder if that is not what he has in mind. Of course, that corrosion occurs at temperatures of 1200 degrees Fahr. or in excess of that. We found that nickel alloys are not suitable for carbonate.

Chairman Harper: Our time is rather limited, and I think we would better proceed to the next paper, "Furnace Atmospheres and Their Relation to Formation of Scale," by Mr. G. C. McCormick, assistant metallurgist of the Crompton & Knowles Loom Works of Worcester, Mass.

Mr. V. E. Hillman will read Mr. McCormick's paper which was published in the August, 1922, issue of TRANSACTIONS.

Mr. Hillman: My assistant prepared this paper, and I shall attempt to defend it for him in the discussion which follows:

Discussion of Mr. McCormick's Paper

Chairman Harper: We have a communication here from Alvan L. Davis of Waterbury, Conn., in answer to Mr. McCormick's paper on certain points. Is Mr. Davis in the room?

Mr. Davis: Yes, I am here. I hadn't anticipated being able to come here. Mr. Chairman and fellow members: I was very much interested in the paper, but it seemed to me we ought to make a little distinction, perhaps, that hadn't been as clearly drawn as I would like to see it in speaking of neutral atmospheres. The distinctive qualities of a neutral atmosphere in a heating furnace are not in my opinion correctly defined by Mr. McCormick, who seeks to distinguish between what may be termed a theoretically neutral atmosphere, and an atmosphere which is practically neutral, or non-oxidizing. I do not believe that any such distinction should be made because a neutral atmosphere must be either, (1) an atmosphere free from any ingredient (not merely free oxygen) having an oxidizing tendency, and also free from any ingredient having a reducing tendency; or (2) it must contain both oxidizing and reducing ingredients, but present in such relative proportions as to secure a balanced condition at the given temperature under consideration and for the specified substance, such as steel, that is exposed to the atmosphere. That is, a neutral atmosphere must be defined as one that is in fact neutral, under such temperature conditions as exist for the operation in question.

It is well recognized, both in theory and in practice, that an atmosphere composed of CO_2 gas is powerfully oxidizing, to metallic substances, such as iron, at high temperatures; and the higher the temperature the more oxidizing is the action of CO_2, which tends to split up, yielding oxygen and CO. And the same is true of H_2O vapor. On the other hand, it is recognized that CO gas is reducing under certain conditions, and a mixture of CO and CO_2 gases may be made, where the oxidizing influence of the one is just offset by the reducing tendency of the other. The relative proportions of CO and CO_2 to give such a neutral atmosphere will vary with the temperature. A larger proportion of CO is needed to prevent oxidation (of iron) as the temperature increases. The experience of skilled hardeners of tool steel confirms this fact, by the necessity of feeding a greater excess of gas, or oil, to the burner in order to prevent scaling, when running the furnace at higher temperatures.

The proper control of the gases in an open muffle heating furnace will almost completely avoid the formation of scale, even when working at extremely high temperatures such as required for hardening high speed steel, where a temperature of 2350 degrees Fahr. is often used. At such a temperature but little CO_2 can be present if the hardened pieces are to come out white and clean. The very high proportion of CO present in furnace gases under such conditions is shown by the manner in which these gases freely burn when they come in contact with the air at the door of the muffle. A considerable outward pressure is maintained so that the movement of gas is always from the muffle door outwards, and no air from the room circulates inward into the muffle.

According to the equilibrium diagram for Fe, FeO, Fe_3O_4, CO, and CO_2, published in *Chemical and Metallurgical Engineering* based upon work reported by Baur and Glaessner in *Zeitung Physik Chem.* 1903 Pg. 354, the relation of CO to CO_2 (by volume) necessary in order to

avoid oxidation of iron, must be approximately as shown in the following table, for the various temperatures noted.

Temperature Degrees Cent.	Temperature Degrees Fahr.	Ratio of CO to CO_2 (By Vol.) to avoid oxidation of Fe to FeO)
680	1256	1.3 to 1
745	1373	1.4 to 1
830	1526	1.8 to 1
890	1634	2.3 to 1
935	1715	3.0 to 1

Chairman Harper: I do not know whether Mr. Hillman wants to reply to this or not. If not, a copy will be transmitted to him and Mr. McCormick and they can make written answer to it as they see fit.

Mr. Hillman: I wish to make a few remarks. I think a discussion will clarify the question. With reference to the practical reducing atmosphere, is that what you challenge, sir?

Mr. Davis: It seems to me rather unfortunate to describe as a neutral atmosphere one having a considerable proportion of carbon dioxide gas when it is recognized it is such a powerful oxidizing agent at high temperatures.

Mr. Hillman: The only reason we made reference to the practical atmosphere is to feature that atmosphere which the furnace operator tries to maintain by manipulating the valves. Admittedly there is only one reducing atmosphere, and that is a true reducing atmosphere, but every heat treating department has what they call a reducing atmosphere, and that is what we referred to as a practical reducing atmosphere, because we obtained it by practical results, by going to a furnace in the heat treating department and making an attempt to create a reducing atmosphere by juggling the valves. That is what you will find a hardener trying to do. These experiments were not carried on in a laboratory furnace. We went to the forge shop and asked the man to develop what he called a neutral or reducing atmosphere. After he was finished with the furnace, then we conducted our experiments. I think the point is well taken, however. You make reference to the fact also that if you have the proper relation of carbon dioxide to that of carbon monoxide, you may prevent the formation of scale. In other words, a certain ratio exists equivalent to a constant. Do you know what that constant is, sir?

Mr. Davis: I think perhaps it is best expressed in this last table, that is to say, the ratio would be a little different, the higher the heat the more you have to have of the carbon monoxide gas in order to avoid that effect.

Mr. Hillman: Do you know of any practical way whereby the CO_2 may be juggled so you can create an atmosphere that will not create scale?

Mr. Davis: In our case we are using gas, and not oil. We use a semimuffle type of furnace, originally built for oil, the type that everyone uses as a rule, I forget whether they happen to be Tate-Jones furnaces, but we turned them over and used illuminating gas that gave us perfect control under a certain mixture of air to start with, under pressure, and driven in, and we can actually bring out high-speed steel pretty nearly white out of that furnace.

Mr. Hillman: Do you want this body to believe that you can take

any kind of a furnace and juggle the valves and heat a carbon tool in there without scaling?

Mr. Davis: We haven't used this particular furnace for ordinary tool steels, that is done in a lead pot. But on high-speed steel where you get into the higher temperatures, it is used wholly. We did have similar burners, however, for this, to those which are used on some other furnaces, where you can practically eliminate it.

I might, while I am speaking, perhaps raise one point, and that is this: you have measured your oxidation by weighing the piece before and afterwards. You oxidize it and then you seek to free it by a very clever device, heating in your cyanide and going through your cleaning operation, but the question suggests itself whether when you put the oxidized surface into the cyanide bath, which is highly reducing, you don't actually reduce back, perhaps, some of the scale to the form of metallic iron.

Mr. Hillman: That is removed.

Mr. Davis: If it were actually reduced, in toto, back, then it wouldn't be removed. Then you would merely remove the oxygen and you wouldn't measure the oxidation really taking place. That might be shed off when you quench it, as you scale anything in quenching. So I raised the question as to whether that means of determining the amount of oxidation is fully accurate. It may be, but I should think some question might arise as to whether or not a thin film of oxide on the scale on the surface of the piece put into a cyanide bath might not in the cyanide bath be fully reduced back to the metallic condition, and virtually none of it shed off afterwards when quenched.

Mr. Hillman: When scale is formed it consists of an iron oxide. Is that right?

Mr. Davis: Yes.

Mr. Hillman: When you remove that scale and it is free from the metal, what bearing has it on the investigation if some of that iron oxide is reduced to metallic iron?

Mr. Davis: I presume you can take the oxidized piece and pack it with sufficient charcoal in any pipe and reduce it right back to the metallic condition. I am not sure whether you got rid of it here. You may have done the same thing, perhaps.

Mr. Hillman: We cleaned our specimens. I would like to go back to your other question again, sir, in preventing the formation of scale. I think it is a very good point if this gentleman can establish the fact that he can prevent the formation of scale by juggling the atmosphere in the furnace.

Mr. Davis: I think there is no doubt but what you would absolutely prevent it if you reached the proportions shown here, which, however, are very high in their content of carbon monoxide. We have come very close to doing that thing under the most exacting conditions, which are those of the high temperature, where you are treatting high-speed steel.

Mr. Hillman: How do you juggle the constant by allowing the inflow of air and city gas?

Mr. Davis: We have it absolutely under control with two valves. Our city gas is first mixed under pressure.

Mr. Hillman: What city do you refer to?

Mr. Davis: Our city is Waterbury, Conn. It is mixed, as I said, under pressure, with a reasonable amount of air, so it is, while not explosive, a very readily combustible mixture. We have an aperture which can be closed more or less which permits the sucking in of any amount of the atmosphere that we want. Now it will actually burn if we don't suck in any, or practically none, but it burns and produces almost pure CO gas. In other words, we could, I think, with that reach almost pure carbon monoxide with the addition, of course, of nitrogen and various other small proportions of gas there. In other words, we have a contrivance whereby we can reach furnace conditions that we never were able to approach before.

Mr. Hillman: Did you ever analyze the gas from the furnace?

Mr. Davis: No, but as I see it issue from the door of the furnace it burns freely. It is a combustible gas as it comes out of the muffle door.

Mr. Hillman: Well, in taking this up, the gentleman seems to contend that he can heat a carbon tool steel furnace without scaling. I suppose I will have to yield on that.

Chairman Harper: I will give this copy to Mr. Hillman and we will look forward to a full answer in the TRANSACTIONS of this gentleman's paper, also, perhaps, he will have some further reply. We have a few minutes for a little further discussion, but before going into that I want to say the committee, due to some mistaken arrangement in the program, has put another paper upon this program, and Mr. Ipsen will give his talk on the "Selection of Electrical Furnaces for Steel Treating" immediately following Mr. Vanick's paper, and this session is expected to run until 1:00 o'clock. There will be a few minutes more for Mr. McCormick's and Mr. Hillman's paper.

Mr. d'Arcambal: In the first place, I have never seen a furnace heating steel from 1400 up to 2400 degrees Fahr. whether oil-fired, gas-fired, or electrically heated, or induction or any other type where you can heat up parts and not get some scaling. We have tried all kinds of reducing atmospheres and every type of furnace, and while it is true on high-speed steel you get very little scaling, nevertheless, you do get some scaling, and any of you gentlemen, if you have any such furnaces, I would very much like to talk with you after the meeting.

On the second proposition, I notice Mr. Hillman, that all your specimens were cyanide treated before being calibrated, and weighed. Do you not believe that the carburizing and nitrogenizing action of the cyanide bath has some effect on your different grades of steel? In other words, have you compared the samples that were cyanide treated before calibrating and weighing with samples that were surfaced, ground, and then calibrated, weighed and tested?

Mr. Hillman: We didn't do that, sir. I hardly see where that is material. Could you just give us a little more information on the subject?

Mr. d'Arcambal: If you take a piece of steel and treat it in cyanide at 1450 degrees Fahr. for ten minutes, you have around .3 of a per cent of nitrogen going part way into the surface, and you will probably have

.30 or .40 per cent carbon. In that case you have a different proposition than you have with steel that is not so treated.

Mr. Hillman: I think that is a very good point. That is, you bring out the fact that you are likely to create an imperceptible film there which will not act the same under these various atmospheres as a piece of metal that was not given that treatment.

Mr. d'Arcambal: Of course, that might not have any action of that kind.

Mr. Hillman: I think that is a very good point. We will make an effort to surface grind some of them, as per your suggestion, and see what results we get.

Mr. Bellis: Mr. Davis' discussion has brought up a very interesting point. Shouldn't a neutral atmosphere be defined as one that is neutral to the material being treated? If we accept that definition of a neutral atmosphere, a reducing atmosphere will be one that will take the oxygen away from the steel, will it not? I would like to have Mr. Davis and Mr. Hillman's views jibe on that proposition. Will the reducing atmosphere reduce the scale? Aren't we using the wrong phraseology there, and shouldn't we start with some definitions of what is a neutral and what is a reducing atmosphere? I understand Mr. Hillman's use of the word has been purely shop.

Mr. Hillman: Those terms are admittedly wrong, they are misnomers, and I think if the A. S. S. T. would adopt a new nomenclature, it would do much toward clearing up some of the mistaken conceptions that exist with regard to a neutral and a reducing atmosphere. Those terms mean nothing at all. It is something like oxidized steel, oxides and nitrides of steel, I think those are also terms that need to be clarified.

Mr. Blasko: Isn't it possible that part of the scale formed was due to passing the pieces through the air before quenching them?

Mr. Hillman: I think that is perfectly natural to assume that that happened, that an imperceptible quantity of scale formed in transit from the furnace to the quenching tank. That is a well recognized fact, I think.

Mr. Blasko: Supposing you had taken a furnace and you tried to keep the same atmosphere in the furnace by passing the gases through. Suppose we had a sealed furnace with those gases in, and in passing the pieces through, naturally the first piece will have scale, to a certain extent. Isn't that true? The pieces that pass through after that would scale less and less, then, until finally we might reach a point where there would be no scaling whatever. Did you try to seal a furnace and pass pieces through it continuously?

Mr. Hillman: No, but I think you are to be complimented in reaching the keynote of the situation, that you are going to get different results from still atmospheres than you will in moving atmospheres. That is a very good point. These are only for gases that sweep through the furnace, and in all heat treating work you are going to have more or less convectional currents, and that is why we selected this atmosphere, because we thought it would approach practical conditions, as near as possible. But you will get entirely different results if you have still atmospheres in the furnace.

Mr. Blasko: I have tried that, sealing the furnace on both ends;

there is air in there, of course; then heat it and pass the pieces through. In about six or seven hours, I don't know just how many pieces were passed through, something like thirty or forty, but you could notice the oxidation was very pronounced at first, but it kept on getting less and less, and the last pieces were only discolored.

Mr. McCormick's reply to the questions raised by Mr. Davis are as follows:

Mr. Davis' exceptions to the definition of the neutral atmosphere are in the writer's opinion well taken. However erroneous the writer's definition is, Mr. Davis' attention is directed to the first statement in the original paper under the paragraph "Kinds of Atmosphere," which is as follows.

In furnace literature, frequent mention is made of 'oxidizing,' 'neutral' and 'reducing' atmospheres.

It is almost unnecessary to point out that the quotation marks about the words oxidizing, neutral and reducing are intended to indicate not the accurate technical meanings of the words but rather the meaning of the words as they are popularly though oftentimes erroneously and equivocally used.

It was the writer's purpose to bring out the fact that the so-called "neutral" atmosphere while balanced as far as combustion is concerned is nevertheless oxidizing to steel. On this point the apparent divergent views coincide exactly.

With reference to the adjustment of the gas-air ratio, Mr. Davis claims that he and his associates are able to bring high-speed steel from the furnace "pretty nearly white."

As the writer's paper does not consider the scaling of high-speed steel, it is necessary to forego extended discussion. It might be added, however, that Mr. Davis' success in eliminating furnace scale on high-speed steel is quite remarkable and not exactly in accordance with the experiences of some of his contemporaries.

Mr. Davis remarked further that "some question might arise as to whether or not a thin film of oxide on the scale on the surface of the piece put in to a cyanide bath might not in the cyanide bath, be fully reduced back to the metallic condition and *virtually none of it shed off afterward when quenched.*"

Mr. Hillman ably answered this objection and in reference to the italicised clause, the writer merely wishes to call Mr. Davis' attention to the fact that even though the scale may be completely reduced to metallic iron, nevertheless the reaction takes place at a temperature far below the fusing point of iron and consequently it is difficult to conceive of a union between the iron reduced from the scale and the original steel of the test specimen.

Mr. Davis' discussion presents the $CO:CO_2$ ratios for equilibrium, in the system Fe, FeO, Fe_3O_4, CO and CO_2. The ratios necessary to effect equilibrium as quoted by Mr. Davis are, if we are not greatly in error, results secured from the investigation of "still" systems. In attempting to utilize these ratios in heat treating furnaces, this fact is extremely important and should not be overlooked as it is generally admitted that the equilibrium constants for moving systems (the majority of heat treating atmospheres) are different from the equilibrium constants of still systems under identical temperature conditions.

The effect of the cyaniding on the response of the surface of the steel to scaling as cited by Mr. d'Arcambal is an important objection which undoubtedly may have some influence on the accuracy of the results of the investigation. However, in a research conducted in our laboratory some time ago, we found the depth of cyanide case induced in 10 minutes at 1450 degrees Fahr. to be .002 inches. These results were secured on test specimens which possessed only 1/3 the mass of the test specimens used in the scaling investigation.

Considering in addition to the variation in mass the correspondingly greater time interval which would be required to bring the test pieces to a heat at which the cyanide would be effective, it is doubtful if the depth of cyanide case induced in 10 minutes of the scale pieces would exceed .001 inch. The carbon and nitrogen in this case undoubtedly would influence the scale formation of the specimen in later heats but the error at best cannot be extremely large.

Mr. Blasko's account of the decreased scaling activity of a scaled furnace through which pieces of steel were passed comprises some valuable information concerning the scaling activity of furnace atmospheres.

A complete account of the work to which Mr. Blasko has reference would be an interesting contribution to the meager knowledge of the scaling activity of furnace atmospheres.

Chairman Harper: I am sorry, gentlemen, that our time is getting short, but I am sure that Mr. McCormick and Mr. Hillman will be very glad to answer any written discussion that you may care to present to them. The editor of the TRANSACTIONS is endeavoring to promote this idea of written discussions in order that the writers of these papers can answer them more fully after studying them in detail. He wishes me to urge you to send in written discussions on these various papers. I am sorry, but we will have to proceed to the next paper, which is by Mr. J. S. Vanick of the Bureau of Standards of Washington, on "Thermal Transformation of Some Chrome Vanadium Steels."

Mr. Vanick read his paper. The discussion of this paper will be published at the time when the paper is published in full in TRANSACTIONS.

Following Mr. Vanick's presentation, Mr. C. L. Ipsen, designing engineer, industrial heating department, of the General Electric Co., Schenectady, N. Y., presented his paper entitled "The Selection of Electric Furnaces for Steel Treating." This paper will be published at a later date in TRANSACTIONS.

DISCUSSIONS OF PAPERS PRESENTED BEFORE THE TECNICAL SESSION OF THE DETROIT CONVENTION OF THE SOCIETY, FRIDAY MORNING, OCTOBER 6

THE Friday morning technical session of the society's convention held in Detroit Oct. 2-7 was called to order at 10 a. m. by Chairman R. S. Archer, metallurgist with the Aluminum Company of America, Cleveland.

Chairman Archer: We have two papers on the program this morning, one by Mr. Knerr of the United States Navy on "Duralumin Forgings" and one by Dr. Anson Hayes, Professor of chemistry at Iowa State College and Professor W. J. Diedricks, assistant professor of mechanical engineering, on the "Rapid Graphitization of White Cast Iron with a Discussion of the Resulting Products."

Mr. Knerr is not with us having been kept away, I believe, by illness and he has asked me to present an abstract of his paper. The original paper is considerably longer. It is mostly a summary of information from various sources on aluminum forgings, their properties and heat treatment.

Mr. Archer read the abstract of Mr. Knerr's paper interpolating the following remarks during and after the reading.

In connection with the relative stiffness of parts made of steel and of aluminum alloys, it is to be remembered that the low modulus of elasticity of aluminum is offset by its low specific gravity and the fact that the stiffness of a beam is a function of the fourth power of its linear dimensions. The result is that if we design beams of similar rectangular cross section, for example, of steel and of aluminum alloy in such a way that the stiffness of the two beams is the same, then the weight of the aluminum beam is 60 per cent that of the steel beam. This applies to any alloy of aluminum and steel of any composition, since the elastic modulus is not appreciably affected by small changes in composition or by heat treatment or mechanical working.

One of Mr. Knerr's statements may create a misleading impression. He states that duralumin ingots weigh from 50 to 75 pounds. This might give rise to the impression that forged or rolled pieces of greater weight could not be manufactured. As a matter of fact, we have made ingots weighing up to 180 pounds for large forging and could make them larger if called for.

A number of the forgings now being made commercially of high tensile aluminum alloys come under the class of automobile hardware and are used largely because of the fine finish which can be imparted to them and which resists corrosion and tarnish very well. Such parts are largely substituting nickel-plated parts.

It may be mentioned that duralumin of the composition used for rolled and forged products is not a suitable alloy for castings even when heat treated. The strength and especially the elongation are disappointingly low. Other compositions can be used which with the proper heat treatment give very much stronger and rougher castings.

The long sections used in the construction of airplanes and dirigibles are usually made by forming a ribbon of sheet. The ribbon is coiled and heat treated in this shape and then shortly after quenching it is formed into the desired section before it has had a time to harden

greatly by aging. After being thus formed it does not require further heat treatment so the problem of warping is very much simplified.

While freshly quenched duralumin sheet is fairly easy to form cold, the annealed sheet is still easier to work and will stand reforming operations not possible with the quenched material. If the annealed material is used, however, it must be heat treated after forming which involves the possibility of warping. In case of assembled structures held together by rivets the subjection of the piece to heat treatment would cause the rivets to lose their hold.

Mr. Knerr recommends the salt bath for the heat treatment of duralumin and as a means of heating the metal for forging. A salt bath has many advantages especially for heating thin sections like sheet. It has serious disadvantages, however, in the case of larger pieces and particularly when heating for forging. In the latter case, the molten salt which adheres to the metal spatters when the metal is forged and is apt to inflict painful burns. An electric furnace is preferable to salt for heat treating forgings and for heating preliminary to forging although the latter operation can be conducted with a less expensive furnace.

The fact that the mechanical properties of the aluminum alloys do not deteriorate at very low temperatures, but rather improve is considered rather important in the construction of aircraft where very low temperatures are apt to be encountered in flight.

The electric welding of duralumin does not appear to be commercially successful at present. Gas welding appears to be the best. Mr. Knerr has contributed an article to the *Automotive Industries* on the method of welding.

If there is any discussion or any questions they will be taken down and forwarded to Mr. Knerr. In the meantime, I will be glad to answer any questions which may seem proper in this connection.

Mr. McCleary: I would like to ask, if it is the proper place to ask, what physical or chemical changes take place during the aging.

Chairman Archer: The theory of heat treatment and aging is quite fully discussed by Mr. Knerr in his paper, but I have omitted this discussion at present, because it is rather involved and the time is too short to enter into it fully. Briefly, duralumin in the freshly quenched conditions contains copper and magnesium silicide in solid solution. This solid solution is unstable and decomposes during aging with the precipitation of the hard compounds $CuAl_2$ and Mg_2Si in the form of very small particles. This precipitation is held to be the cause of age hardening.

Mr. Wise: What is the function of manganese?

Chairman Archer: The practical effect of manganese is to increase the tensile strength. It forms a hard compound $MnAl_3$ which hardens and strengthens the alloy. There is also probably a grain refining effect.

Mr. Wise: Iron does not do the same thing?

Chairman Archer: No.

Mr. Curran: What is the temperature range of extrusion. Is it in the forging range.

Chairman Archer: The small tubes just passed around were ex-

truded cold, but the usual practice on larger pieces is to extrude hot.

Mr. Curran: In what type of furnace are the long pieces heat treated.

Chairman Archer: The long sections are heat treated in the form of a coil before being formed, using a salt bath.

Mr. Curran: Assuming that you would have a long piece of 5 or 6 feet, how would it be heat treated?

Chairman Archer: If you had thin metal and a large salt pot, I would say that would be the most economical way to handle it, but with a section of any thickness I should prefer an electric furnace.

Mr. Curran: Another question with regard to welding thin sheets. Is it possible to weld thin sheets, say as thin as 0.014 inch.

Chairman Archer: I believe it is possible, although the difficulty probably increases as the sheet becomes thinner.

Mr. Curran: Have you had any experience with spot welding of the thinner sheets?

Chairman Archer: No. Spot welding has been attempted by a number of firms but I have not personally encountered any satisfactory results. The spot welding is hindered by the presence of thin films of aluminum oxide on the surface of the metal.

Mr. Harder: I want to inquire if there is any difficulty experienced in design where a number of the parts are of duralumin and some of the parts are of steel because of the difference in the modulus of elasticity.

Chairman Archer: The difference in elastic modulus must, of course be recognized in design. With proper allowance for this factor no difficulty should be experienced.

Mr. Percival: Have any members of the society had experience in extruding the material and what is the character of the die they used. We have tried to extrude the material on mandrils and have found difficulty from the metal sticking to the mandril.

Chairman Archer: If there is anyone here that could throw any light on this question we would be very glad to hear from them.

(No response)

Mr. Percival: The same thing holds with regard to pure aluminum.

Chairman Archer: Are there any other questions on the dualumin paper?

(none)

There is one further topic on which I should like to make a few remarks and that is on the name "duralumin." This, as has been indicated from Mr. Knerr's paper, is a German trade name derived from the name of the factoy that originally made the metal in Germany. It is objectionable to use a trade name to designate a class of alloys. The alloy to which their word duralumin refers is rather definitely an alloy containing aluminum, copper and magnesium and usually manganese. This is not the only high tensile aluminum alloy suitable for rolled and forged products. Therefore, I would suggest that in referring to high tensile aluminum forgings we should say aluminum alloy forgings rather than duralumin forgings. Duralumin is not the only alloy available and it is just as illogical to use that term to cover all forgings as it is to designate all steel connecting rods by the trade name of one alloy steel

such as chrome-molybdenum or U. M. A. Duralumin is merely one of a number of aluminum alloys suitable for forgings.

Another point in this connection is that in the case of aluminum alloys as in the case of steel, the cost of fabrication increases in general with the physical properties required. You do not ask for high chrome nickel steel forgings when straight carbon steel forgings will do just as well. Likewise, if a user specifies higher physical properties than he actually needs in aluminum forgings he is apt to pay a higher price than is necessary. For example, a tensile strength of 60,000 pounds per square inch is not required for an automobile door handle.

The next paper on the Rapid Graphitization of White Cast Iron will be presented by Dr. Hayes.

Dr. Hayes: I realize this probably is outside of the field of most of your interests, and realize also the position I am putting myself in in presenting a paper on this subject. It has been said that whenever a young genius comes forward with a rapid method of graphitization, we always take his statements with extreme misgivings. I wish to state also, that being in connection with an educational institution, we realize that we are apt to be a few jumps behind industrial development, and I wish to state also that a paper written by H. A. Schwartz of the National Malleable Castings Company, which appeared in September of this year presents some of the material which I will present in this paper. However, I believe there are some considerable points that will be of interest, in addition to what has already been presented by other workers.

Dr. Hayes read his paper.

The discussion of this paper will appear at the time when the paper is published in TRANSACTIONS.

Steel is Steel

(*Continued from Page* 306)

or better. This is not conjecture but fact based on actual occurrence, and the difference in practice represents an important item in the production of heat treated parts.

Steel is steel; but it requires study and investigation, separation and selection, carefulness in handling, judgment in the choice of stock, determination of proper treatment and accuracy in carrying out that treatment—then may profitable production be maintained with a product that will be a source of pride to the manufacturer and of satisfaction to the consumer.

CHARACTERISTICS OF AIR COOLING CURVES

By E. J. Janitzky

Radiation and Convention

BY COOLING a solid body from any given temperature, under the assumption that it does not possess transformation points similar to those of steel, we note that, at the start, as the metal has the highest temperature, only a short time is required for equal temperature drop, whereas with further drop of temperature the time is considerably increased. The temperature drop of steel or iron, for instance, will not be continuous, but will show interruptions or retardation at certain points.

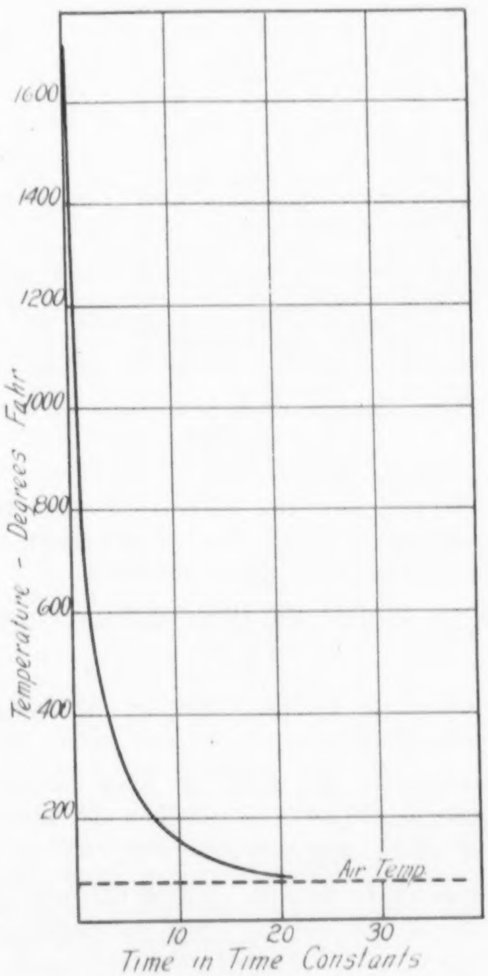


Fig. 1—Chart Replotted from Time-Temperature Chart Plotted on Instrument

By plotting the time as the abcissa and the temperature as the ordinate we obtain a curve of the shape as shown in Fig. 1 which was replotted from the spherical temperature recording pyrometer chart of Fig. 2. These curves are generally referred to in the pertaining literature to be of logarithmic char-

A paper written for TRANSACTIONS. The author, E. J. Janitzky is metallurgical engineer, The Illinois Steel Co., South Chicago, Ill.

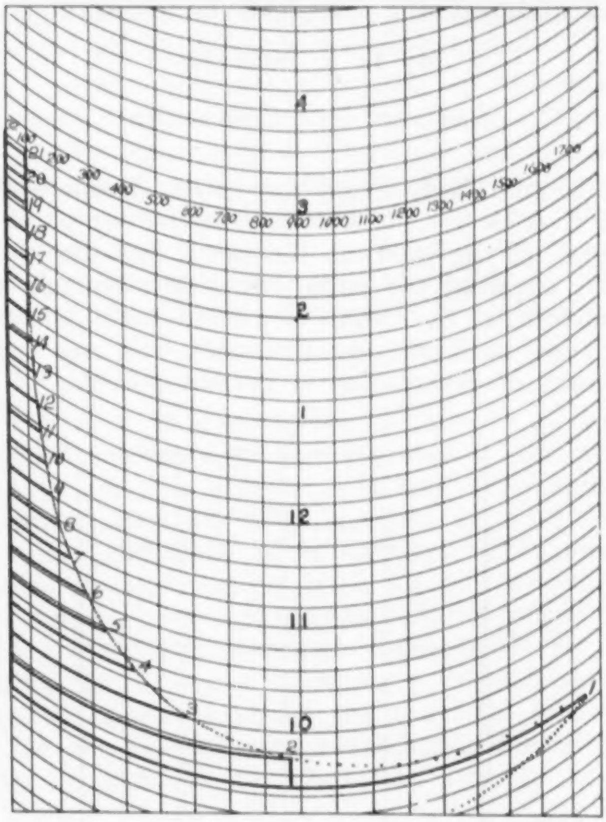


Fig. 2—Time-Temperature Chart as Recorded on Instrument.

acter. The writer, however, does not intend to interfere with the prevalent contentions but endeavors to present his observations on cooling curves in air (radiation, convection) and their characteristics.

Before going into thé subject the three different processes of heat transfer may be recalled:

> 1. *Convection is the transfer of heat by moving matter, for example, by hot air which can be felt rising from any hot body.*
>
> 2. *Conduction is the flow of heat through and by means of matter unaccompanied by any motion of matter, for example, the passage of heat along an iron bar one end of which is held in fire.*
>
> 3. *Radiation is the passage of heat through space, but without the necessary presence of matter, for example, the passage of heat through the vacuum of an incandescent lamp.*

The writer cooled cylindrical nickel specimens from different maximum temperatures in air as shown in the accompanying charts. The size of the specimen was ⅞ inch in diameter and 2.5 inches in length with a central hole of 7-32 inch half the length of the specimen for inserting the pyrometer couple. The couple was of nickel chrome and connected to a time temperature recorder as made by the Brown Instrument Company of Philadelphia, and with a duplex thermo-couple usually used for thermal analysis. The heating was performed in a circular resistance electric furnace of 2.5 inches in diameter and 3 inches in depth. The travelling speed of the paper was

.22 inch per 3.5 minutes—.22 inch represents the small time interval spacing on the chart.

It was found that the results of time temperature curves of the air cooling specimens, lend themselves to simple calculation and the data obtained are very useful in metallurgical cooling problems. The salient point of the mathematical procedure is the adoption of a time constant, or in other words to ascertain the time which is required to half way cool the range from its maximum temperature to zero in the Fahrenheit scale. Having the constant in linear length and plotting it in multiples from zero on the X axis which represents the time co-ordinate, one obtains by projecting the units of the time constants as ordinates, as visible on Figs. 2 and 3, until its intersection with the actual curve whose points coincide with temperature numerals t° derived by dividing the maximum temperature T° by the amount of time constants t or their fractions elapsed during cooling, plus one, or t+1.

Table I

Size of Nickel Specimen 7/8" Diameter and 2½" in Length

T° Maximum Temp.	Temperature As read off Degrees F.	Temperature t° $t^\circ = \frac{T^\circ}{t+1}$ Temperature As calculated Degrees F.	t As elapsed in constants t=.295 In.=4.69 Minutes	Time T $\frac{}{T=tm}$ In Minutes
1750 ° F.	1750	1750	0	0
	1170	1170	.5	2.34
	875	875	1	4.69
	580	585	2	9.38
	445	437	3	14.07
	340	350	4	18.76
	285	290	5	23.45
	240	250	6	28.14
	210	218	7	32.83
	180	194	8	37.52
	160	175	9	42.21
	90	87	19	89.11
	85	83	20	93.80
	87	80	21	98.49
Air Temp. 80° F.				

Table II

Size of Nickel Specimen 7/8" in Diameter and 2½" in Length

Maximum Temp.			t=.885 In.1=4 Min.	
540° F.	540	540	0	0
	370	360	.5	7
	270	270	1	14
	170	180	2	28
	130	135	3	42
	105	108	4	56
	95	90	5	70
Air Temp. 74° F.				

The formula mathematically expressed will read:

$$t^\circ = \frac{T^\circ}{t+1}$$

and the actual time T=tm, m being the time of the time constant in minutes, seconds or hours, t the amount of time constants elapsed. The time constant

increases with decreasing of the maximum temperature to which the body was heated before cooling, and may be derived from a standard curve for lower temperatures, by projecting the temperature for which it may be desired on the X axis and drawing half way through the temperature range a parallel which intersects the standard curve and the ordinate. The linear

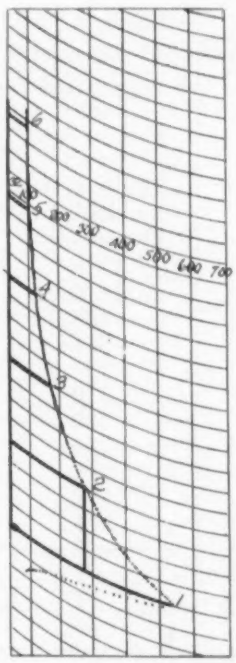


Fig. 3—Time-Temperature Chart
Plotted on Instrument

length represents the time constant for the particular temperature. Obviously the time constant holds good only for the same shape, size and mass.

For larger masses of geometrical similarity, the time constant increases in a manner as the surface per cubic inch decreases with increased sections, namely hyperbolic. Tables I and II give actual and calculated data obtained from 2 curves.

In respect to specimens where the curve is interrupted by a transformation point, one has to deal with two curves, namely, the one representing the temperature drop from the maximum temperature to the start of the transformation, and the other one setting in at the temperature after the heat evolution is completed to atmospheric temperature.

Both curves practically represent a unit, which is, however, interrupted by the time of the transformation period, and the lower part of the curve. Obviously this is only a shifting parallel to the time axis, which represents the amount of time required in passing through the transformation point.

In concluding, the writer wishes to state, that by using the time constant as outlined above, reasonable data can be obtained of bodies cooled to ordinary atmospheric temperature.

The Question Box

A Column Devoted to the Asking, Answering and Discussing of Practical Questions in Heat Treatment—Members Submitting Answers and Discussions Are Requested to Refer to Serial Numbers of Questions.

NEW QUESTIONS

QUESTION 56. *Which is the best method of producing large forgings, pressing or hammering?*

QUESTION 57. *Does repeated heating just above the critical range with subsequent quenching of a steel specimen injure its physical properties?*

QUESTION 58. *What is the cause of brittleness resulting from the carburizing of steel?*

QUESTION 59. *Is a sulphur content of* .067 *per cent detrimental to the proper carburizing of a low carbon steel having low a manganese and phosphorus content?*

QUESTION 60. *What is the cause of distortion of carburized parts of regular conformations?*

ANSWERS TO OLD QUESTIONS

QUESTION NO. 27. *What is the function of the high phosphorus and the high sulphur content in the so called automatic screw stock steel?*

QUESTION NO. 35. *What is the difference between red annealed and blue annealed sheet steel?*

QUESTION NO. 38. *What regulations are recommended to reduce the fire hazzard of quenching tanks?*

QUESTION NO. 48. *What are dendrites and how may they be detected?*

QUESTION NO. 49. *Can dendrites be removed through a proper heat treatment?*

QUESTION 51. *What are the causes of black fractures in high carbon tool steel?*

ANSWER. By H. A. Schwartz, Manager of Research, National Malleable Castings Co., Cleveland, Ohio. The separation of secondary graphite (temper carbon) at some stage of heat treatment has been dealt with in the August 9 issue of *Chemical and Metallurgical Engineering* by A. W. F. Green, in a paper entitled "Black Fractures in Carbon Tool Steel."

This paper by Mr. Green was discussed by several metallurgists in subsequent issues of *Chemical and Metallurgical Engineering.*

QUESTION 52. *Is the Brinell hardness number of a given piece of steel, an accurate measure of its machinability?*

ANSWER. By H. A. Schwartz, Manager of Research, National Malleable Castings Company, Cleveland, Ohio.

The machineability of no material can be inferred from its Brinell number. It is probably true that a given material heat treated to a given Brinell number will always give the same machining properties. Examples where Brinell number does not go with machineability are Hadfield manganese steel, having only moderate Brinell hardness but an indefinitely high resistance to cutting. Malleable cast iron and wrought iron have identical Brinell numbers but the former machines much more freely.

QUESTION 53. *What is the composition of the so-called semi-steel?*

QUESTION 54. *Is it possible for a piece of commercially pure iron in contact with a piece of high carbon steel, to absorb carbon from the steel?*

ANSWER. By H. A. Schwartz, Manager of Research, National Malleable Castings Company, Cleveland, Ohio.

The ability of commercially pure carbonless iron to absorb carbon from a specimen of steel when maintained in close contact with the steel at temperatures above the Ac_3 point, has often been demonstrated. Perhaps the most recent demonstration on a quantitative basis was performed by Messrs. Klopsch and Roberts, students of Case School of Applied Science who were carrying out this work in the writer's laboratory.

QUESTION 55. *What are the causes of soft spots in the carburizing of steel?*

ANSWER. While this question is one of a general nature it must necessarily be answered in a general way.

The most frequent cause of soft spots is faulty heating during the carburizing period. Close observation invariably discloses the fact that the soft spot occurred where the temperature would be the lowest inside the carburizing box.

As an example—in a certain plant manufacturing gasoline motors, it was

the practice to pack 500 piston pins in a single carburizing box. Almost a fixed percentage of them were always rejected for softness and yet the practice was persisted in, in spite of the constant loss, because "production must be kept up."

A survey of the difficulty showed that the method of packing, was responsible for the trouble. The pins were packed in such a solid mass that uniform diffusion of heat throughout such a mass, within the few hours allowed for the operation, was impossible. Soft spots are more generally met with than entire surface softness and usually are more easily explained.

Soft spots may also be caused by the parts coming into contact with each other through careless packing, or they may occur in parts placed near the top of the box with too little carburizer over them to allow for the shrinkage that always takes place, especially when the carburizer is new.

One of the frequent causes for soft spots is due to decarburization which may possibly occur during long reheating in an open furnace preparatory to hardening. If there is an excess of air in the reheating furnace there would be a tendency for the carbon to be burnt out of the surface of the steel.

Abstracts of Technical Articles

Brief Reviews of Publications of Interest to Metallurgists and Steel Treaters

SERVICE FOR MEMBERS

The Library Bureau of the American Society for Steel Treating is operated to give to the members quickly, reliably and at the minimum expense the following service:

1. A complete copy of the magazine article referred to in any periodical you may be reading.
2. A Translation of foreign articles that would help you with your work.
3. A list of references to books and articles on any metallurgical subject.
4. Informing the members of new articles of interest to them as an engineer.

The Library Bureau makes the entire field of literature available to every member, distance is eliminated, for it will copy the desired information and send it to you. It also helps the busy man by supplying information without any expenditure of his time. The charge for this personal work is merely its cost.

The Library Service does not obtain any profit from the work, but does this to make the information contained in the large libraries with which it has connection available to every member. The rates are as follows:

Photo Print Copies of articles, drawings, etc., 25c per 10 x 14-inch sheets.
Searches, abstracts, etc., $2.00 an hour.
Translations, $6.00 per thousand words for French or German: $7.50 and upwards for other languages.
Reference card service, giving reference to current magazine articles, $10.00 a year in advance, and 5c for each card mailed.

Members desiring to avail themselves of this service should address Library Bureau, American Society for Steel Treating, 4600 Prospect Ave., Cleveland, Ohio.

AUTOMATIC ELECTRIC TEMPERATURE-REGULATING SYSTEM FOR FURNACES. By I. William Chubb, editor European edition, *American Machinist*, Vol. 57 No. 18.

The above article gives an account of the temperature controls used by Adolphe Saurer in their plant at Switzerland.

In the coke and coal heated furnaces the temperature is automatically controlled by varying the position of the dampers; where gas, oil and electricity are employed it is somewhat different.

The system controls six furnaces working equally well, whether the temperature

in these furnaces is the same or different, the heat being varied by controlling the drafts in the chimney with a slide, which is itself controlled by the electric regulating device described in the article.

STEEL REQUIREMENTS OF THE AUTOMOTIVE INDUSTRY. By Harry Chandler, Metallurgist the C. H. Wills Co., Marysville, Mich., in *Iron Age*, Vol. 110, No. 18, pages 1136, 1137.

The author points out that the mechanical characteristic of the steel in automobile manufacture is of prime importance. A classification of the various parts in an automobile and the group each represent is given, as well as the test used to determine the mechanical properties.

The importance of heat treating is emphasized and the statement made that the physical properties of steels are a direct function of the drawing temperature. The author points out where alloys steels are best adopted for certain parts.

THE ELECTRIC FURNACE IN REFINING IRON AND STEEL. By Dr. John A. Mathews, Pres. Crucible Steel Co. of America in *Iron Age*, Vol. 110, No. 18, pages 1127-1130.

The author gives the present status of the electric furnace and also reasons for the world-wide expansion in the use of electric furnaces. The importance of clean steel is forcibly presented, and the part played by the electric furnace in producing this grade of steel is also brought forward. The mechanical and electrical refinements that have been made are mentioned as well as a discussion of the versatilities of the electric furnace.

NON-METALLIC INCLUSIONS AND FERRITE SEGREGATIONS IN STEEL. By E. G. Mahin and H. W. Botts, Department of Chemistry, Purdue University, in *Chemical and Metallurgical Engineering*, Vol. 27, No. 20.

This paper points out that the segregation of ferrite about non-metallic inclusions is a phenomena that has long been familiar to metallurgists. However, differences in opinion of observers as to the cause of these segregations are prevalent. Most of the theories that have been proposed are familiar to students of metallurgy. One of the authors points out that several of the theories advanced do not account satisfactorily for all of the observed cases. It is pointed out that manganese and sulphide are present in steel surrounding a sulphide inclusions that cause the precipitation of ferrite shells.

These tiny inclusions have much to do with the locus of the excess ferrite.

THE PROBLEM OF PIG IRON SPECIFICATIONS. By Wm. R. Webster, Consulting Engineer, Philadelphia, Pa., in *Raw Materials*, November, 1922.

This paper discusses the chemical requirements of pig iron ordered by various foundries making the same grade and weight of castings, showing that the specifications and requirements vary considerably and cause the blast furnace men unnecessary trouble as they are called upon to make several grades of pig iron for the same weight and grade of casting.

The author summarizes the various grades of pig iron which can be obtained in the United States.

HANDLING MATERIAL IN AN AUTOMOTIVE PLANT. By M. R. Dennison, Studebaker Corporation, South Bend, Indiana, in *Iron Age*, Volume 110, No. 20, November 16th, 1922.

This article outlines the system in use at the Studebaker plant for the handling of automotive material. It is illustrated with numerous photographs taken throughout the plant showing tractors hauling trains of boxes throughout the plant. Also conveyor devices and overhead cranes.

INVAR, ELINVAR AND OTHER NICKEL STEELS. No. 2. By Wallace Dent Williams in *Raw Materials*, November, 1922.

This is the second of a series of articles dealing with the development in the metallurgy of nickel steels. The paper contains numerous equilibrium diagrams for various ferro-nickel alloys, also it includes charts showing the thermo-critical points of specific steels and the mechanical properties of the steels. This paper will be of considerable interest to those studying nickel and nickel alloys.

VERY PURE ALLOYS OF ELECTROLYTIC IRON, CARBON AND MANGANESE. By Robert E. Neville and John R. Cain, Associate Chemist and Research Associate respectively U. S. Bureau of Standards, in *Raw Materials,* November, 1922.

This paper describes the preparation and the mechanical properties of an extensive series of electrolytic-iron, carbon and manganese. The specific effect on pure iron of additions of manganese, additions of carbon and additions of carbon and manganese are thoroughly described.

POWER PLANT COST OF OPERATING HAMMERS. By R. E. Waldron in *Forging and Heat Treating,* October, 1922.

For economical hammer operation the unit must be in a good state of repair and adjustment, the evaporation rate from boilers must be as high as is possible, and least amount of coal possible should be used in getting boilers into operation. The paper discusses the steam consumption per hour for various sized hammers.

FORGING FURNACE CONSTRUCTION. By H. Johnson in *Forging and Heat Treating*. October, 1922.

The results of tests emphasizing the necessity of sufficient combustion space and the value of insulating brick are discussed. The reverberatory flame, proper oil temperature and atomization are important points brought out in the paper. Sufficient free air to complete combustion is vital.

TECHNICAL CONTROL OF THE McCOOK FIELD FOUNDRY. By E. H. Dix, Jr., in the *Metal Trade*. November, 1922.

This paper points out the advantages that have been obtained through the system of control of the foundry for making aircraft castings. A close check is kept on melting equipment, temperature control, casting temperatures, physical properties of castings, metallographic examinations and finally the correlation of tests and data.

FIRECLAY REFRACTORIES. By Alan G. Wikoff, in *Chemical and Metallurgical Engineering*. Nov. 15, 1922.

This paper outlines the manufacturing operations at the Laclede-Christy Clay Products Co., of St. Louis. Dry press and stiff mud process fireclay brick are discussed. The manufacture of special shapes, glass house refractories and washed pot clay are reviewed.

BURNING LIQUID FUEL IN FURNACES. By R. C. Helm, in *Iron Trade Review*. Nov. 9, 1922.

Fuel oil and tar have gained considerable favor in metallurgical operations during recent years. Many types of burners designed including those for open hearths are described. Principles of combustion are also discussed.

STEELS FOR AUTOMOBILE CONSTRUCTION. By Benno R. Dierfeld, in *Iron Age*. Nov. 9, 1922.

The author reviews the standardized steel specifications in vogue in the German automotive industry, pointing out what the various symbols and designations mean.

HEATING FURNACES FOR BLOOMS, SLABS AND BILLETS. By W. P. Chandler, Jr., in *Iron Age*.

A discussion of the two main types of furnaces for heating blooms and billets. Considerable data is given in which the results of tests show greater efficiency of the continuous recuperative type than in the regenerative furnace.

PRESENT STATUS OF THE ELECTRIC FURNACE IN REFINING IRON AND STEEL. By John A. Mathews in *Chemical and Metallurgical Engineering*. Nov. 1, 1922.

A brief review of the developments in steel making methods leading up to the electric furnace development. The flexibility of the electric furnace and the quality of its output has established its sound position. As consumers realize the importance and economy of using clean steel a greater demand for increased electric furnace tonnage is at hand.

THE PROPERTIES OF COLD-WORKED METALS. By Zay Jeffries and R. S. Archer in *Chemical and Metallurgical Engineering*. Nov. 1, 1922.

The authors explain the properties of cold-worked metals by a series of postulates regarding conditions at slip planes. The general theory has been checked by experiments on copper, nickel, iron, molybdenum and tungsten.

Reviews of Recent Patents

1,418,984. Electric Furnace. Frederick W. Sperr, Jr., and Harold J. Rose, of Pittsburgh, Pennsylvania, assignors to the Koppers Company, of Pittsburgh, Pennsylvania, a corporation of Pennsylvania.

The present invention relates to furnaces, and more particularly to electric furnaces for testing materials. The present invention is illustrated as embodied in an electric furnace for heating coal samples.

The object of the invention is to produce a furnace of this character in which the heating can be accurately and readily controlled. The furnace is so constructed that when used for heating a tube containing a coal sample, the sample may be heated progressively in such a way as to closely simulate the coking conditions of a byproduct coke oven.

1,420,980. Process of Manufacturing Electrical Resistance Material. Ferdinand Eichenberger, Aarau, Switzerland, assignor to the firm S. A. Kummler & Matter, Aarau, Switzerland.

The invention relates to a new and improved process of manufacturing electrical resistance material which stands low, intermediate and high temperatures.

The novel process consists in that silicon carbide is used as a base to which calcium carbonate, oxide of metals and graphite are mixed to vary the coefficient of resistance.

1,421,205. Work Holding and Feeding Device for Grinding or Polishing Machines. Rufus W. Fuller, Deerfield, Mass., assignor to Production Machine Co., Greenfield, Mass., a corporation of Massachusetts.

The invention relates to machines for grinding or polishing articles of cylindrical form, and more particularly to work holding and feeding devices for such machines.

1,421,429. Air-circulating system for industrial ovens. William C. Ehmka, Detroit, Mich., assignor to Detroit Sheet Metal Works, Detroit, Mich.

An oven in combination with an air heating apparatus, a circulating system, a circulating fan, an exhaust fan, means for operating same, upper and lower exhaust chambers, an intake pipe connecting the circulating fan with the upper exhaust chamber of the oven, a separate air intake breather also connected with the circulating fan intake, mean for regulating the proportions of hot air from the exhaust chamber to the fresh air from the intake breather as it enters the fan, and means for distributing same through the oven, and means for exhausting the air from the oven through the exhaust fan.

1,422,019. Alloy of Refractory Metals and Process of Forming Same. John Adam Yunck, South Orange, N. J.

This invention relates to an alloy of tungsten and thorium particularly useful in making metal filaments and incandescent lamps, and a method of making same. Various alloys of the refractory metals have been proposed for this purpose

because the alloys are usually more ductile than their constituents taken separately, but none of such alloys heretofore proposed have been successful for the purpose because they either had too low a fusing point, or volatilized at high temperatures and discolored the lamp bulb.

1,422,096. Alloy containing iron, nickel, chromium. Pierre Girin, Paris, France, assignor to Societe Anonyme de Commentry Fourchambault & Decazeville, Paris, France.

An alloy of iron, nickel, chromium and manganese, containing nickel, 20 to 25 per cent, chromium, 10 to 15 per cent, manganese, 1 to 2 per cent, carbon, 0.2 to 0.5 per cent, such alloy having, together with the mechanical qualities of the best steels, a high resistance to attack by strong acids, organic acids and alkalis, in solution or in fusion.

1,422,672. Thermocouple. Thomas G. Goghlan, Wellsburg, W. Va.

A thermo-couple comprising different metals forming a union and means comprisinb an open chamber for housing said union so as to permit its exposure to heat transfer from gaseous products of combustion and prevent its ignition of an unexploded fluid adapted for providing such gaseous products.

1,422,710. Process of annealing malleable cast iron. Charles T. Holcroft, Detroit, Mich.

The method of annealing malleable iron castings which consists in exposing the material to temperatures variable in a definite progression, such progression being effective to raise the temperature of the material at a rate proportionate to the thermal conductivity to a predetermined point of reaction, to maintain reaction temperature for a predetermined time, and then to lower the temperature to a point below which rapid cooling will not injuriously affect the material.

1,423,022. Oil Burner. Austin A. Riley, Indianapolis, Ind., assignor of two-thirds to Central States Bridge Co., Indianapolis, Ind., a corporation of Indiana.

The object of this invention is to provide an oil burner in which air to effect complete combustion is provided in quantities regulated to suit the supply of oil, and in a manner to thoroughly nebulize the oil in a chamber provided within the nozzle, before discharge for ignition.

1,423,128. Sand-Blast Apparatus. Hugo F. Liedtke, Hagerstown, Md., assignor to Pangborn Corp., Hagerstown, Md., a corporation of Maryland.

This invention relates to sand-blast apparatus for cleaning castings or like purposes, of the type in which a sand-blast nozzle is movably mounted in a chamber or cabinet into which the castings or articles to be treated by the sand blast are transported by a movable carrier which also effects their delivery from the sand-blast chamber.

1,423,338. Alloy and the Method of Producing Same. Clemens A. Laise, Weehawken, N. J., assignor by Mesne Assignments, to General Electric Co., Schenectady, N. Y., a corporation of New York.

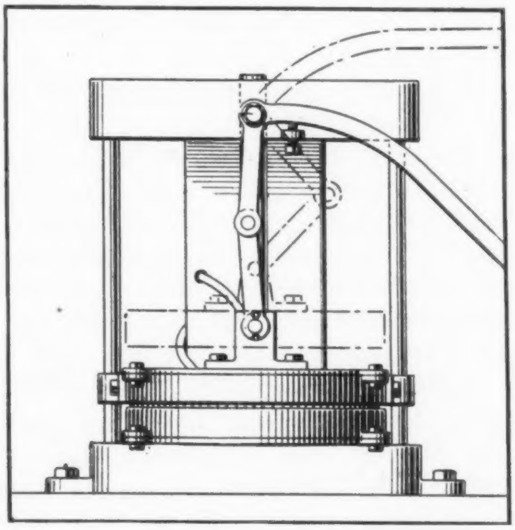
This invention relates to a new and useful alloy and to the method of producing the same. It relates more particularly to the production of an alloy that shall possess desirable properties which make it especially suitable for uses as electrical

contacts, magneto points, targets and sheet metal for wireless equipment, and wire for heating and lighting elements. It includes gold, tungsten, calcium vanadate and thorium oxide.

A. J. Harry, 1315 East 143rd Street, Cleveland.

A member of the American Society for Steel Treating has recently patented a new press which in addition to providing the necessary heat treatment to saws and flat tools, exerts sufficient pressure on the work to prevent its warping after removal from the press. A view of this electrically heated press for saws and flat tools is shown in the accompanying sketch.

The device consists of a base plate and a movable top plate which is raised and lowered by means of a handle and crank arm. Both plates are heated electrically by means of coils placed inside, the temperature being indicated by a thermocouple.



High-speed steel articles such as disk saws usually are treated in a furnace to a temperature of 2250 degrees Fahr., after which they are quenched by being subjected to a lower temperature about 1150 degrees Fahr. This scond step is accomplished by quenching the tools into an oil bath at room temperature, after which they are drawn at 1150 degrees Fahr.

With the new machine the saws are removed from the furnace and placed between the plates and subjected to pressure, the heating elements being operated at the same time to cool the work down from 2250 degrees Fahr. to 1150 degrees Fahr., or the red hardness point. It is claimed that the saws are maintained straight and the mechanical and structural conditions are such that no further heat treatment is required.

News of the Chapters

SCHEDULED REGULAR MEETING NIGHTS

FOR the convenience of visiting members, those chapters having regular meeting nights are listed below. It is desired that all secretaries whose chapters are not included in the list should communicate with the National Office in order that the list may be as complete as possible.

Boston—Second Tuesday
Bridgeport—Thursday between 20th and end of month
Chicago—Second Thursday
Cincinnati—Second Thursday
Cleveland—Fourth Friday, Cleveland Engineering Society Rooms, Hotel Winton; meeting at 8:00 p. m.
Detroit—Second and fourth Monday. For meeting place call W. G. Calkins, Secy. Detroit Twist Drill Co.
Hartford—Friday nearest 10th of month
Indianapolis—Second Monday
Lehigh Valley—No regular night
New Haven—Third Friday
New York—Third Wednesday
Philadelphia—Last Friday
Pittsburgh—First Tuesday
Providence—No regular night. Nov. 10th, Dec. 12th.
Schenectady—Third Tuesday
Springfield—Third Friday
South Bend—Second Wednesday
St. Louis—Third Monday
Syracuse—No regular night
Tri City—Thursday
Washington—Third Friday
Rockford—Second Friday following the second Thursday

STANDING OF THE CHAPTERS

New members amounting to 156 were added during the month of October as compared with 45 new members during September. The large number of new members is indeed an excellent showing, but it must be borne in mind that probably half of the new members were secured at the convention at Detroit, and it does not necessarily portray extended activities on the part of the chapters, with the possible exception of Detroit.

It is also interesting to note that the largest chapter in the American Society for Steel Treating at the present time is the Detroit Chapter. This is the first time that Chicago has ever been out of the lead, and much credit is due to the Detroit Chapter under the leadership of membership chairman W. E. Blythe for the excellent showing.

The following explanation will be of assistance. The chapters shown in capitals have advanced their position from that occupied in the previous report. Those shown in italics are not occupying as high a position as

in the previous report. Those printed in regular type, (ie, Pittsburgh and Philadelphia) are occupying the same position as in the previous reports.

The standing is as follows:

1. DETROIT
2. *Chicago*
3. Pittsburgh •
4. Philadelphia
5. Cleveland
6. New York
7. Hartford
8. Milwaukee
9. Boston
10. Lehigh Valley
11. SYRACUSE
12. WORCESTER
13. *Indianapolis*
14. NORTH WEST
15. *Rockford*
16. **Cincinnati*
17. *SPRINGFIELD
18. **Washington*
19. *Tri City
20. Providence
21. *BUFFALO
22. *SCHENECTADY
23. ST. LOUIS
24. *New Haven*
25. SOUTH BEND
26. *Toronto*
27. Rochester
28. Bridgeport

*Tied

BOSTON CHAPTER

One hundred and forty members and guests of the Boston chapter gathered at the plant of the Consolidated Gas Company in order to be present at the regular November meeting. The first part of the evening was turned over to the presentation of a six-reel moving picture showing "The Story of the Automobile." The picture was very well received. The second portion of the program was the explanation by Mr. W. W. Cummings, Industrial Engineer for the Boston Consolidated Gas Co., of the manufacture of gas.

A miniature plant in actual operation was prepared so those present were able to follow each individual step in the manufacture of gas, even a miniature house was shown in which the gas being produced by the miniature plant was used.

National President, T. D. Lynch, Second Vice President, W. S. Bidle, and National Secretary W. H. Eisenman were present at the meeting and extended the greetings of the National Society to the membership. At the close of the meeting a buffet luncheon was served by the Gas Company, and everyone agreed that the evening had been a most profitable and enjoyable one.

This is the third of a series of meetings held by the Boston chapter in local plants, where actual demonstration of various heat treating equipment is shown, and where things are accomplished under actual working conditions.

The next meeting will be held in the laboratories of the Massachusetts Institute of Technology.

CHICAGO CHAPTER

The Chicago chapter held its November meeting Thursday evening, Nov. 9 at 8 p. m. in the Chicago City club rooms, Plymouth Court and Jackson boulevard.

H. J. French, physicist of the United States Bureau of Standards was

the speaker of the evening. He presented a very interesting paper entitled "Some Factors Affecting the Heat Treatment of Steel."

Mr. French, who has had wide experience in heat treatment and study of the properties of steels and alloys, delivered a very interesting talk, which was instructive and very valuable to all who were there.

Following Mr. French's paper a lengthy and interesting discussion ensued. This meeting proved to be one of the best of the year, as evidenced by the large turn out.

CINCINNATI CHAPTER

The Cincinnati chapter of the American Society for Steel Treating held a joint meeting on Nov. 16, at 8 p. m. in the Literary club rooms, 25 E. 8th street, Cincinnati, O. The speaker for this meeting was R. H. Sweetser, Assistant to the Vice President of the American Rolling Mill Co., Columbus, O., who discussed very fully the "Making of Pig Iron."

Mr. Sweetser was particularly well fitted to tell the story of pig iron, as in addition to his connection with the American Rolling Mill company he is president of the Southern Pig Iron & Coke association and is vice president of the Portsmouth By-Product Coke company.

Mr. Sweetser's talk was illustrated by a moving picture firm showing a modern blast furnace in operation.

The meeting was well attended and proved to be a very entertaining and instructive talk.

CLEVELAND CHAPTER

The Cleveland chapter of the society held its November meeting on Tuesday evening the 21st. This meeting was a joint meeting with the American Institute of Mining and Metallurgical Engineers, the Cleveland Engineering Society and the American Society of Mechanical Engineers.

The speaker for this meeting was Dr. J. A. Mathews, president of the Crucible Steel Co. of America, who presented a very capable and interesting paper entitled "Alloy Tool Steels." Dr. Mathews holds an unique position in the industrial world. He is an eminent metallurgist, having contributed very largely to the development of alloy steels during his experimental and research days and now he holds the position as chief executive of one of the large steel companies of this country.

Dr. Mathews presented some very interesting information relative to alloy tool steels. Following this paper an interesting and comprehensive discussion was held.

About 200 members and guests were present.

DETROIT CHAPTER

The November 13th bimonthly meeting of the Detroit Chapter was very well attended. Well over a hundred members were present to hear Mr. E. G. Steadman of the Timken Roller Bearing Co., Canton, O., plant, who read a paper on Electric Furnace Melting Practice. He presented the subject

from the standpoint of the furnace operator, from the preparation of the charges to the rolling into blooms. Lively discussion followed the reading of his paper.

HARTFORD CHAPTER

The Hartford chapter held its regular monthly meeting Friday, Nov. 17 in the assembly hall, Hartford Electric Light Co., Pearl street, Hartford, Conn.

Major A. E. Bellis, the speaker of the evening, presented an interesting paper entitled "Salt Baths for Heat Treating." Major Bellis, formerly of the Springfield Arsenal and now head of the Bellis Heat Treating Co., New Haven, has had wide experience in the development and application of mixtures of salts suitable for use as heating mediums in the heat treatment of steel. Major Bellis discussed the requirements of salt baths for treating carbon and alloy steels, and showed to what extent the salt bath is now used to meet these requirements. Specimens of hardened tools and parts were exhibited to illustrate the advantages and possibilities of the salt bath method of hardening.

By special arrangements with the Hartford Electric Light company and the General Electric company, several types of electric furnaces, ovens and drawing baths were on exhibition in the hall. These instruments were in operation and were demonstrated by a representative of the General Electric company.

INDIANAPOLIS CHAPTER

The regular monthly meeting of Indianapolis Chapter was held the evening of the 13th at the Hoosier Athletic Club. The meeting was held following a dinner. Dinner meetings have not been held by the Chapter for some time, this being the first in over a year. There were ninety-six present at dinner, making it the biggest meeting on record for this chapter.

The meeting was opened at 8:15 and a paper was presented by Mr. H. E. Hayward, Metallurgist of the Link-Belt Co., of this city. Mr. Hayward's paper was entitled "Practical Applications of Metallography." Mr. Hayward had spent considerable time in preparing his subject and selecting slides to illustrate his paper. A microscope was at hand and after the presentation of the paper, Mr. Hayward exhibited interesting specimens of steels treated to give various conditions.

Following the paper, discussion was held in connection with the proposed course in Heat Treatment, that is being organized by Indianapolis Chapter. Prof. John Keller of Purdue University was at hand and told us of the Purdue Extension service and how the Chapter could obtain his assistance in helping us carry out the plan of the course.

Many representatives of various concerns around the city were present at the meeting and over thirty signified their intentions to enroll in the proposed course. At the present time, the date of the opening of the

course has not been definitely decided but it is thought that it will probably not begin before the first of January.

SOUTH BEND CHAPTER

The South Bend chapter held a meeting on Nov. 8, at the Studebaker Cafeteria, plant No. 2. This meeting was in the form of a smoker. Seventy-one guests were present. S. M. Havens, National Director, spoke in general and in detail regarding the National Society and its relationship to the chapters.

Mr. Havens' talk was very well received, and proved of much interest, and it is believed will result in much good for both the chapter and the National Society.

Following Mr. Havens' talk, W. J. Harris, a member of the South Bend chapter read a paper entitled "Some Phases of the Machinability of Steel."

This paper was well received and very interesting. The discussion on this paper will be held at the next meeting in December.

Professor Keller of Purdue university was the main speaker for this meeting and delivered a very interesting lecture entitled "Why Steel Warps." He illustrated his paper very ably and interestingly by the use of charts and diagrams. Professor Keller's paper proved of great interest to all present, as he is an authority on the heat treatment of steel.

MILWAUKEE CHAPTER

The Milwaukee chapter held a meeting Monday evening, Nov. 6, 1922, 8 p. m. at the Blatz hotel. The red invitation cards, which the secretary had sent out announcing this meeting did some very good work, as it brought out 53 guests to dine with Mr. Havens and Mr. MacKenzie.

Following the dinner, which was served at 6:45 p. m. about 90 members and guests came in to attend the lecture and moving picture exhibition depicting the manner in which alloy steels are made at the plant of the Interstate Iron & Steel Co.

Mr. W. J. MacKenzie of the Interstate Iron & Steel Co. lectured during the exhibition of the moving picture films.

Mr. S. M. Havens addressed the assembly on matters pertaining to the National Society as well to the local chapter.

We are glad to note that the Milwaukee chapter members are showing such a fine spirit of co-operation, and it is only through such cooperation that the aim of our society can be realized to the utmost.

NEW HAVEN CHAPTER

Mr. R. J. Allen of the Rolls Royce Company of America, Springfield, Mass., and first Vice President of the American Society for Steel Treating, addressed the members of the Society Friday evening, Nov. 17th. Mr. Allen spoke very interestingly and entertainingly on the subject of the Testing of Steel. And the presentation of this paper brought out many valuable points.

Following the meeting an election of officers was held with the following results:

Chairman: Major Reuben A. Hill, First Vice-President, and Secretary Marlin Fire Arms Corporation, New Haven, Conn.

Vice-Chairman: Professor C. H. Mathewson, Professor of Metallurgy, Yale Scientific School, New Haven, Conn.

MAJOR REUBEN A. HILL
Chairman of the New Haven Chapter

Secretary and Treasurer: Mr. Walter G. Aurand, Chief Chemist, R. Wallace & Sons Mfg. Co., Wallingford, Conn.

The New Haven Chapter is quite sure that the activities of the chapter for the coming year will be well taken care of with such a capable list of officers.

NEW YORK CHAPTER

About 75 members gathered at the Machinery Club, 50 Church St., in order to attend the regular November meeting and to hear a paper presented by L. H. Fry, Metallurgist of the Standard Steel Car Company, Burnham, Pa., on the subject of Hammered and Pressed Forgings.

Mr. Fry handled his subject in an exceptionally capable manner, showing the various stages through which the large forgings produced by his firm must be taken. Mr. Fry pointed out particularly that the principal concern in producing of a proper forging was involved in the proper making of

the steel. He compared the result obtained by hammer forging and also the result obtained by pressing, pointing out the advantages and disadvantages of each method.

A very interesting discussion took place at the close of Mr. Fry's paper, in which a large number of the members participated.

National President, T. D. Lynch, Second Vice President, W. S. Bidle and National Secretary, W. H. Eisenman, were in attendance at the meeting and extended greetings to the chapter.

NORTH-WEST WEST CHAPTER

The first meeting of the North-West West chapter of the society was held Nov. 15 in the club rooms of the Manufacturers Club, Builders Exchange building, Minneapolis.

This meeting was devoted to a technical subject, presented by E. C. Smith, metallurgical engineer, with the Central Steel Co., Massillon, O., who spoke on the subject of "Steel Used in Automotive construction."

Mr. Smith's subject covered forging stock, sheets and strips and was well illustrated with stereopticon slides, showing the manufacture of these materials.

Mr. Smith presented his subject in a very capable manner, as was evidenced by the large amount of interesting discussion which followed his paper. It was well received and an interest to all those who were in attendance.

PHILADELPHIA CHAPTER

The regular meeting of the Philadelphia Chapter was held at the Engineers Club on Spruce St., Friday evening, Nov. 24th. The program was arranged especially for the Student members of the Chapter and included a motion picture, giving the phases in modern Steel Manufacture. These pictures were shown through the courtesy of the Midvale-Cambria Steel Co., and were explained by Mr. George A. Richardson. The pictures were only recently released and were of very remarkable value. They showed the process of the manufacture from the ore to the finished produce.

In addition to the moving picture, there was a practical lecture by Dr. Walter M. Mitchell, Consulting Metallurgist of Philadelphia, and a member of the Executive Committee of the local chapter. Dr. Mitchell's subject was "The Heat Treatment of Steel, its Purpose and What It Accomplishes." Dr. Mitchell has the rare faculty of being able to lecture in such a way that intricate problems were rendered very simple. He prepared his talk so that it would explain to the students some of the very fascinating and important phases of steel treating, which are necessary in order that the fullest benefits may be obtained.

President T. D. Lynch was present at the meeting, and extended a message to the local chapter from the National Society.

PITTSBURGH CHAPTER

Tuesday evening, Nov. 7, the Pittsburgh chapter of the American Society for Steel Treating held its regular monthly meeting in the

main dining room of the Hotel Chatham. Some 75 members were present for dinner to hear the report of J. V. Emmons, National treasurer of the society.

Following Mr. Emmons' talk William J. Priestly, formerly of the United States Naval Ordnance plant at Charleston, West Virginia, presented an illustrated paper covering in an informal way the manner in which operations were conducted in the manufacture of large shells, armor plate and gun forgings. He pointed out that the particular feature of interest of this plant was the manner in which they duplexed their steel. The steel is first refined in a 75 to 90-ton open hearth furnace and from there transferred by means of ladles to two 55-ton capacity electric steel furnaces which remove the sulphur, oxides and the last of the impurities in the steel. The steel is then cast into fluted ingots for manufacture of the large shells and gun parts and into comparatively wide thin ingots for armor plate.

Mr. Priestly pointed out that they found in their practice that a top cast ingot with a hot top, with the taper running from top to bottom, being wider at the top than at the bottom, proved most satisfactory. The fluted ingots did not contain as pronounced curves as is usually the case, and were regarded by Mr. Priestly as far superior to the usual fluted type.

The heavier ingots were forged under a press some idea of whose gigantic size may be gained from the fact that the columns were 30 inches in diameter. A four or five-inch hole was drilled through the entire length of these columns to make certain that they were of sound steel. Recuperative producer-gas furnaces of the car type were used in heating for forging and in heat treating these unwieldy masses of steel. Mr. Priestly mentioned the fact that the troublesome snowflakes were avoided at this plant by careful practice in pouring at the correct temperature and in forging and heating.

This plant has been closed down since the limitation of armament conference.

In closing Mr. Priestly gave as his opinion that electric steel is not necessary in most commercial work for open hearth steel can be made on a quality and quantity basis to meet most requirements of the present day.

The members greatly enjoyed the entertainment provided by Misses Braumers and Langestras and the old fashioned singing school which they inaugurated.

RHODE ISLAND CHAPTER

The Rhode Island Chapter of the A. S. S. T. held their regular November meeting at the Engineers' Club, Friday, November 10th. The principal address of the evening was presented by Mr. J. N. Voltmann of the W. S. Rockwell Co., New York City. Mr. Voltmann is an authority on furnaces and dealt with his subject in a very interesting manner. His talk was illustrated by lantern slides, showing the various types of furnaces best suited for production in different manufacturing progress.

National Secretary W. H. Eisenman spoke to the members with reference to the activities and services of the National Society. About 75 were in attendance.

Owing to ill health, Mr. R. H. Schaefer, Chairman of the Rhode Is-

land Chapter found it necessary to resign, and the Chairmanship has been assumed by Mr. F. H. Franklin, Consulting Chemist, 184 Whittier Ave., Providence, R. I., who was the Vice Chairman.

ROCKFORD CHAPTER

The first regular meeting of the season was held October 27th at the Nelson Hotel. Mr. R. G. Guthrie speaking on "Application of Gas in Heat-Treating,—Equipment and Appliances." Mr. Guthrie's lecture was received with much favor. The demands he made for a modern heat treating plant were rather a novelty, but appeared reasonable after he went into details. He pointed out that furnaces should not be considered as merely furnaces, but should be rated with machine tools and therefore deserve to be called heating machines. Mr. Guthrie stated that the laws of radiation are violated in heat treating plants, the color of most heating apparatus being black, instead of white, as it should be. He criticized further the prevailing tendency of insufficient lighting and ventilation, and all together his most interesting paper gave food for much thought, as was proven later on by a lively discussion of the subject. Mr. Guthrie earned everlasting gratitude with the members of the Rockford Chapter, and in a following directors meeting it was decided to ask him to lecture again in the near future.

On November 2nd. about 30 members and guests of the Chapter followed an invitation of the Fairbanks-Morse Company, Beloit, Wisconsin. Under Mr. Chas. Cotta and Mr. H. G. Higgins approved leadership, the delegation got under way in 7 cars furnished by members of the Chapter and arrived in Beloit in good time and without mishap, where officials of the plant received them most cordially and where guides were provided to take the groups to different departments and furnish any information desired. The main feature of the excursion was the huge foundry recently established and working in full swing. This foundry is without doubt the most up-to-date in the middle west. The forge shop was another point of interest. Crank shafts and other forgings of large size being handled with apparent ease. The delegation left the plant late in the afternoon, thoroughly satisfied that the time was well spent. It was unofficially decided then and there that excursions of a similar kind should be arranged at more regular intervals.

At the meeting of November 10th Mr. H. J. French, of the Bureau of Standards, Washington, D. C., spoke on "Some Factors Affecting the Heat Treatment of Steel." His lecture was illustrated by numerous slides. The discussion following Mr. French's paper held members and guests together till 11 P. M. This meeting being especially well attended was one of the most successful ever held by the Rockford Chapter.

Mr. O. H. Olson's resignation as Vice-Chairman was read and accepted with much regret. The members were also informed of the pending attendance and membership contest. There were present a number of out of town guests, and also a number of applications for membership received.

THE SCHENECTADY CHAPTER

A special meeting was held by the Schenectady chapter on the afternoon and evening of Thursday, Nov. 9. About twenty members and guests attended this meeting, among whom was W. H. Eisenman, national secretary of the society. All of those that attended, visited

the plant of the Ludlum Steel company at Watervliet, N. Y., where a profitable and enjoyable time was had.

Mr. P. A. E. Armstrong gave a very interesting talk on "Stainless Steel." Following Mr. Armstrong's talk the Ludlum Steel company entertained those in attendance at a dinner.

Jim Cran and Bill Eisenman kept the crowd amused by their good stories and humorous anecdotes.

Mr. Eisenman was presented with a hand made ash tray by his good friend Jim Cran.

At eight o'clock a business meeting was held at the Rensslaer Polytechnic Institute. Mr. A. C. Cooley addressed the chapter on the "Manufacture and Physical Properties of the Metal Tungsten."

While this paper dealt with a subject that was not exactly a steel treater's subject, the talk was extremely interesting, because of the similarity which exists between the metal tungsten and steel, as well as the peculiar differences which occur in the working of these two materials.

A large number of questions during and following the talk was a measure of the keen interest in this paper.

About fifty members and guests were present during the evening meeting.

SPRINGFIELD CHAPTER

The Springfield Chapter deviated from its usual program and held their November meeting on Friday, the 17th at the Fitzgerald Forging and Heat Treating Company's plant on St. James Avenue, Springfield. Mr. Z. L. Sault, President of the New England Annealing and Tool Company of Boston was present and presented the principal talk of the evening. Mr. Sault not only gave a practical talk but he also demonstrated the heat treatment of steel.

Mr. Sault has had many years experience in the actual hardening of tools and dies, and is one of the very few men who accompanies his talk with an actual demonstration of heat treating.

The Fitzgerald Company was a very pleasant host and had both carbon and high-speed furnaces in operation. The meeting was well attended, about 75 showing their willingness to see the latest methods properly demonstrated.

Mr. W. D. Fuller, Mgr., of the New England Heat Treating Service Company was present and gave a demonstration of the Rockwell Hardness Tester.

Mr. W. H. Eisenman, National Secretary, was present at the meeting, and renewed acquaintanceship with the members of the Chapter and their guests.

ST. LOUIS CHAPTER

The St. Louis chapter of the society held its regular monthly meeting Monday evening, Nov. 20, 1922 at the Annex hotel, Sixth and Market streets.

The meeting was preceded by the usual get-together dinner, which was served at 7 p. m.

Following the usual order of business, the speaker of the evening,

George W. White of the DeRemer-Blatchford Co., Chicago, Ill., presented his paper entitled "Furnaces, Construction and Uses."

Mr. White presented his paper in a very capable manner and brought out very many valuable points in the matter of design of furnaces for a uniform heat treatment.

Many questions and much interesting discussion followed the presentation of this paper.

SYRACUSE CHAPTER

An interesting meeting was held by the Syracuse chapter Nov. 10 at 8 p. m. in the rooms of the Chamber of Commerce, 433 South Warren street, Syracuse, N. Y.

J. D. Cutter, vice president and metallurgist of the Climax Molybdenum company delivered a very capable paper entitled "Molybdenum Steel."

As molybdenum steel has had the lime-light for some time past, Mr. Cutter's paper proved to be very interesting and attractive to the members of the Syracuse chapter, as evidencd by the very good turnout which they had.

WORCESTER CHAPTER

The November meeting of the Worcester chapter was held Thursday evening, the 16th at which time Mr. J. P. Gill, metallurgist of the Vanadium-Alloys Steel company presented his very capable paper entitled "High-Speed Steel from a Practical Standpoint."

Mr. Gill has had wide experience on the manufacture of high-speed steel and spoke with authority on this subject.

Following Mr. Gill's paper a very interesting discussion ensued.

The meeting was very well attended and proved interesting to all.

ADDRESSES OF NEW MEMBERS OF THE AMERICAN SOCIETY FOR STEEL TREATING

EXPLANATION OF ABBREVIATIONS. M represents Member; A repesents Associate Member; S represents Sustaining Member; J represents Junior Member, and Sb represents Subscribing Member. The figure following the letter shows the month in which the membership became effective.

NEW MEMBERS

AAMODT, M. H. G., (M-10) 103 E. 16th St., Minneapolis, Minn.
AMES, W., (M-11), B. C. Ames Co., Waltham, Mass.
ANDERSON, A. J., (M-10), 1303 Monroe St., N. E., Minneapolis, Minn.

CLIMAX MOLYBDENUM COMPANY, (S-11) 61 Broadway, New York City.
CRESSMAN, H. E., (S-10), E. F. Houghton & Co., 1002 Beaufait, Detroit, Mich.

DANZIGER, E. H., (Sb-10), 17 Madison Ave., New York City.
DIBBLE, B. F., (M-10), 303 3rd St., So., Minneapolis, Minn.
DUMAS, M. G., (M-9), 1708 135th St., E. Chicago, Indiana.

GRIFFITH, J. R., (M-11), 934 N. 8th St., Philadelphia, Pa.

HANCOCK, GEO. M., Union Charcoal Chemical Co., Olean, N. Y.
HARMAN, W. H., (S-11), Southwork Fdry. & Mach. Co., 4th and Washington Avenue, Philadelphia, Pa.
HAY, T. N., (A-10), British America Nickel Corp., Ltd., Ottowa, Ont., Can.
HIGGINS, HARRY J., (M-11), 223 Dale St., Waltham, Mass.
HILL, RUEBEN, (M-11), The Marlin Firearms Corp., New Haven, Conn.
HYSLOP, THOS. B., (M-10), 9190 Livernois Ave., Detroit, Mich.

JERRY, H. J., (M-11), 235 Union St., Schnectady, N. Y.
JONES, A. ARTHUR, (M-11), 1810 Jefferson Ave., Philadelphia, Pa.

KLOPSCH, OTTO Z., (M-11), 3250 Highland Pl., Washington, D. C.
KNIGHT, A. L., (A-10) 905, Ogden Ave., Toledo, O.
KRAFT, A. N., (M-11), 41 Mallery Pl., Wilkes Barre, Pa.

LEDIN, THEO. A., (M-9), 71 Gladstone Ave., Detroit, Mich.
LARENZ, F. A., JR., (M-9), Amer. Steel Foundries, Indiana Harbor, Indiana.
LOWE, RUSSELL, (M-11), 147 Varick St., New York City.

MALABY, V. R., (M-11), 5605 Haverford Ave., West Philadelphia, Pa.
MARTIN, H. T., (S-11), Lanston Monotype Mach. Co., 24th & Locust St., Philadelphia, Pa.
McMANNUS, W. H., (M-10), 50 Peterboro St., Detroit, Mich.
MORRMANN, THOS. A., (M-11), 1425 Cedar St., Milwaukee, Wis.

RAINE, C. R., (M-10), Ridge Rd. and Dayton St., Pleasant Ridge, Royal Oak, Michigan.
REINHARDT, G. A., (M-10), Youngstown Sheet & Tube Co., Youngstown, O.
ROBINSON, J. E., (M-11), 1421 Cedar St., Milwaukee, Wis.
RUSSELL, L. S., (A-10), 714 Wisconsin Ave., Oak Park, Ill.

SEARLE, W. C., (M-10), Reed & Prince Mfg. Co., Worcester, Mass.

SHERMAN, D. E., (M-11), 2153 Temple Ct. St., St. Paul, Minn.
STEVENSON, WM., (M-10), 1496 Collingwood Ave., Detroit, Mich.
SPRING, L. W., (M-11), 836 So. Michigan Ave., Chicago, Ill.
SPURRELL, S. S., (M-11), 1205 Bemet St., Lansing, Mich.
SWEDISH CRUCIBLE STEEL CO., Detroit, Mich., (S-11).

TOBIN, C. J., (M-10), 2235 Highland Ave., Detroit, Mich.

UPTHEGROVE, CLAIR, (M-10), 125 Chemistry Bldg., Ann Arbor, Mich.

VAUGHN, Howard A., (S-11), 2114 Carroll Ave., Chicago, Ill.
WOODWARD, R. W., (M-11), The Whitney Mfg. Co., Hartford, Conn.
WILBER, C. L., (M-10), Timken Detroit Axle Co., 136 Clark Ave., Detroit, Mich.

CHANGES OF ADDRESS

CLARK, LORENZO T., from 5793 Kingsbury Pl., St. Louis, Mo., to Leschen Wire Rope Co., St. Louis, Mo.

FOWLER, H. R., from 43 Roughley Rd., Arlington, Mass., to 42 Orchard St., Cambridge, Mass.

FREDERICK, J. B., from 425 Oakley Ave., Rockford, Ill., to 2203 Auburn St., Rockford, Ill.

GLEISSINGER, H. C., from 6337 Charlevoix Ave., Detroit, Mich., to 2999 Bellevue Ave., Detroit, Mich.

GRIGGS, H. L., from 139 E. 66th St., New York City, to Room 1002 Engineering Bldg., 114 Liberty St., New York City.

HARDEN, ALAN F., from 59 Sherman St., Springfield, Mass., to P. O. Box 584, Springfield, Mass.

HINER, W. F., from 15200 Turlington Ave., Harvey, Ill., to 15626 Myrtle Ave., Harvey, Ill.

HUNNINGS, S. V., from 2826 27th St., Washington, D. C., to Weldless Rolled Ring Co., 10022 Detroit Ave., Cleveland, Ohio.

JENNINGS, F. H., from Fox Motor Co. to Engineering Tool Corp., Philadelphia, Pa.

LEKBERG, C. H., from 9814 Ave. H to 10639 Ave. F, Chicago, Ill.

MARBLE, W. H., from 5915 Sturgeon St., Pittsburgh, Pa., to Jones & Laughlin Steel Co., Industrial Engr. Dept., Woodlawn, Pa.

QUADENFIELD, W. A., from Chrome Steel Works, Chrome, to 528 Poplar St., Roselle, N. J.

REEDER, E. R. S., from Ludlum Steel Co., 1008 Marine Trust Bldg., Buffalo, N. Y., to Wheelock Lovejoy Co., 128 Sidney St., Cambridge, Mass.

ROOT, H. H., from 259 Newbury St., Boston, Mass., to 146 Thirty-third St., Whitestone Landing, New York.

SULLIVAN, L. J., from 505 Fourth Ave., College Point, Long Island, N. Y., to 309 First St., Keyport, New Jersey.

SURTEES, R. E., from 2919 Anderdon, Detroit, Mich., to 4134 St. Jean Ave., Detroit, Mich.

WOENER, WM. J., from Rohr St., Rochester, N. Y., to 5 Lundy's Lane, Rochester, N. Y.

Commercial Items of Interest

DOCTOR Samuel L. Hoyt, has recently transferred his research activities from the Nela Park laboratories of the General Electric Co., to the company's laboratories at Schenectady. Doctor Hoyt will continue his research work at Schenectady.

After two years of satisfactory operation with powdered coal firing of 22 sheet and pair and annealing furnaces, the Otis Steel Company has started extensions at their plant in Cleveland for the erection of a complete new strip mill, which provides for powdered coal firing of continuous heating and annealing furnaces.

In this plant, which gives consideration to quality as well as tonnage, it has been found as a result of two years' operation with powdered coal that this method of firing not only is economical and reliable but that the product in general is improved and metal losses are materially reduced.

The complete Quigley system now in use for preparing, distributing and burning the fuel is being extended to serve all furnaces in the new strip mill. Order for the powdered coal equipment has been placed with Quigley Fuel Systems, Inc., 26 Cortlandt Street, New York.

Ethan Viall, former editor of the *American Machinist* will again become connected with this publication in the capacity of editor in the Ohio territory.

Mr. Viall was for ten years on the editorial staff of this publication, and had given up the business interests which formerly had his attention, and has located in Cincinnati at 7474 Lower River Road, Fernbank.

He will devote half his time to editorial work, reserving the remainder for the completion of the several technical books which he has had under way for some time.

E. W. Test of Michigan City plant of the Pullman Company has been made general mechanical engineer of that plant.

M. K. Epstein of Hartford, Conn., who, for some time has been the representative in that territory for Tate-Jones & Company and Wilson-Maeulen Company has changed his line of work, and has given his resignation as representative of the Wilson Maeulen Company. He will be succeeded in that territory by Stanley P. Rockwell of Hartford.

The basic books in the steel industry as selected by leading members of the industry for inclusion in the business library of the McAlpin Hotel of New York were recently announced by L. M. Booner. Among those who have given their selections, from which the final choice will be made are:

Charles M. Schwab, Chairman, Bethlehem Steel Company, New York; George G. Crawford, President, Tennessee Coal, Iron & Railroad Company, Birmingham, Alabama; J. A. Campbell, President, The Youngstown Sheet & Tube Company, Youngstown, Ohio; H. Sanborn Smith, First Vice President, Gulf States Steel Company, Birmingham, Alabama; E. G. Grace, President, Bethlehem Steel Company, Bethlehem, Pa.; J. S. Unger, Manager, Carnegie Steel Company, Central Research Bureau, Pittsburgh, Pa.; A. A. Corey, Jr., Vice President, Midvale Steel & Ordnance Company, Philadelphia; S. W. Tener, American Steel & Wire Company, Cleveland, Ohio; George M. Verity, President, The American Rolling Mill Company, Middletown, Ohio, and John A. Mathews, President, Crucible Steel Company of America, New York City.

These selections came to Mr. Boomer as a result of an inquiry instituted among the leaders in the steel industry to assist him in building up a business library of the ten books in each of twenty industries selected by the leaders of those industries.

MR. SCHWAB chose:

Title	Author
Metallurgy of Steel 2 Volumes	Harbord & Hall
Metallurgy of Iron & Steel	Stoughton
Metallurgy of Cast Iron	Thomas D. West
Manufacture and Properties of Iron & Steel	Harry Huse Campbell
Metallography & Heat Treatment of Iron & Steel	Albert Sauveur
Principles, Operations & Products of the Blast Furnace.	J. E. Johnson, Jr.
Basic Open Hearth Steel Process	Carl Dichman
The Electric Furnace	Alfred Stansfield
The Steel Foundry	John Howe Hall
The Engineering Index	

The Year Book of the American Iron and Steel Institute as well as The Journal of the British Iron and Steel Institute, published in London.

MR. UNGER chose:

Iron & Steel Works Directory of the United States and Canada, 1920	
The Making, Shaping and Treating of Steel	J. M. Camp
Kent's Mechanical Engineer's Pocket Book	
Coal and Coke	Frederick H. Wagner
The Manufacture and Properties of Iron and Steel	Harry H. Campbell

The Abc of Iron and Steel	
Principles of Iron Founding	Moldenke
Principles, Operations and Products of the Blast Furnace	Johnson
Blast Furnace Construction	Johnson
The Ore Deposits of the United States and Canada	James F. Kemp
MR. CRAWFORD chose:	
The Metallography of Steel and Cast Iron	H. M. Howe
Metallurgical Calculations	J. W. Richards
Steel and Its Heat Treatment	D. K. Bullens
The Principles of Iron Founding	Richard Moldenke
The Metallography and Heat Treatment of Iron and Steel	Albert Sauveur
Blast Furnace Construction in America	J. E. Johnson, Jr.
The Principles, Operation and Products of the Blast Furnace	J. E. Johnson, Jr.
The Basic Open Hearth Steel Process	Carl Dichman
The Chemical Analysis of Iron	A. A. Blair
The Metallography and Heat treatment of Iron and Steel	Bradley Stoughton
MR. COREY, JR. chose:	
Principles, Operation and Production of the Blast Furnace	Johnson
Manufacture and Properties of Iron and Steel	Campbell
Iron and Steel	Tieman
Steel—A Manual for Steel Users	Metcalf
The Metallography of Steel and Cast Iron	Howe
The Metallography and Heat Treatment of Iron and Steel	Sauveur
Metallurgical Calculations	Richards
The Making, Shaping and Treating of Steel	Camp & Francis
Cambria Steel Company Handbook	
Electric Furnaces in the Iron & Steel Industry	Roenhauser, Schoenawa & Van Baur
MR. MATHEWS chose:	
Metallurgy of Iron and Steel	Stoughton
Metallography of Steel and Cast Iron	Howe
Electric Furnaces in the Iron and Steel Industry	Van Baur
Materials of Construction	Upton
Heat Treatment of Tool Steels	Brearly
The Inside History of the Carnegie Steel Company	J. H. Bridge
Helmets and Body Armor in Modern Warfare.	Dean
Iron in All Ages	J. H. Swank

In commenting on the gratifying response to his request Mr. Boomer said:

"When I first made public the plans for a business library in the Mc-

Temperature

With the **F. and F. Optical Pyrometer** the temperature is measured by merely observing the object. It is accurate, simple, substantial and direct-reading.

(Write for Booklet)

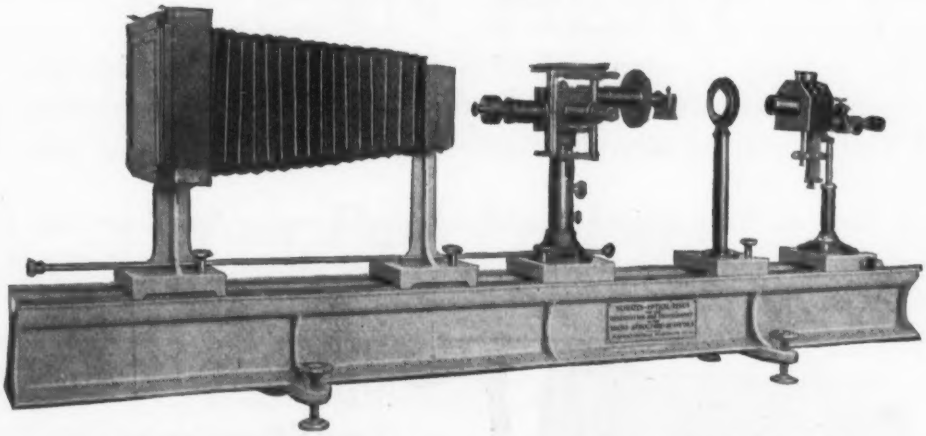
Hardness

The **S. M. Co. Brinell Machine** is the standard machine for measuring hardness of metals adopted by the leading concerns.

Pressure is applied quickly and uniformly; a special feature prevents leakage of the hydraulic fluid.

(Ask for Booklet on Hardness Tests)

Micro-Structure



The **Scimatco Optical Bench** is the advanced outfit used by many of the foremost metallurgical firms for observing and photographing the micro structure of metals.

SCIENTIFIC MATERIALS COMPANY

"Everything for the Laboratory"

PITTSBURGH, PA.

Alpin I was advised that the practical business man had little time for theoretical knowledge such as would be obtained from books. I have before me a very convincing exhibit of replies from leaders in industry to the effect that the business executive not only appreciates the value of a theoretical study of his business, but also values the viewpoint of another man.

"While replies to my letters are still coming in by every mail, it is quite evident from the correspondence already received that the kind of books which treat industrial subjects from the human point of view are more in favor than books of a merely technical character. I have noted a number of comments to the effect that a young man should first read the kind of books that tend to make his business interesting, and read the technical books later to supplement his practical experience.

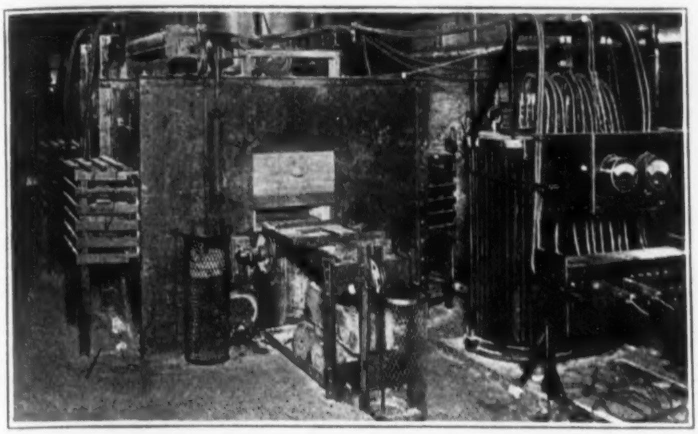
"In addition to a general interest among industrial leaders in the bibliography of our library I have received many helpful suggestions which I believe will make the library both useful and interesting to business men."

Secretary of Commerce Hoover has asked representative engineering societies to propose candidates for the post of Director of the Bureau of Standards to succeed Doctor S. W. Stratton on January 1, when he leaves to become president of the Massachusetts Institute of Technology at Boston. Men now with the bureau will be considered.

Mr. Warren D. Fuller, formerly metallographist of the New Departure Mfg. Co., has become manager of the New England Heat Treating Service Company at Hartford, Conn.

This company is composed of a number of very capable men in the New England territory, and in addition to handling and marketing a number of well known metallurgical accessories, will do a general heat treating business.

The firm is New England representative for the American Gas Furnace Company. The Wilson Maeulen Company and also for the Rockwell Hardness Testers.



Electric Steel Treating Furnace insulated throughout with SIL-O-CEL

To Secure Uniform Heat and Positive Temperatures

apply to your furnaces a layer of SIL-O-CEL Insulation.

SIL-O-CEL is light in weight, highly siliceous, and possesses the lowest heat conductivity of any known material. It withstands extremely high temperatures, acting as a barrier to heat flow through walls and settings, and making it possible to regulate heat with absolute accuracy. Furnished in the form of brick, block, powder and cement, adapted to all types of equipment without change in design.

Complete information contained in Bulletin F-8B sent with blueprints and samples upon request.

CELITE PRODUCTS COMPANY

NEW YORK-11 BROADWAY DETROIT-BOOK BUILDING DENVER-SYMES BUILDING
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CLEVELAND-BULKLEY BLDG ST. LOUIS-RAILWAY EXCHANGE BLDG SAN FRANCISCO-MONADNOCK BLDG
MINNEAPOLIS-251 SIXTH AVENUE, SOUTH NEW ORLEANS-WHITNEY CENTRAL BANK BUILDING

SIL-O-CEL

PREVENTS HEAT PENETRATION

TRADE MARK REGISTERED U.S. PATENT OFFICE

A CELITE PRODUCT

KLEAN HEAT

(TRADE MARK REGISTERED)

(a reheating mixture for hardening steel)
Means just what the name says.

Other Park Products:

Carbonizing Compounds.
Lead Pot Carbon.
Cyanide Hardening Compounds.
Kwick Kase.
Quenching and Drawing Oils.

Park Chemical Company

Detroit, Mich.

The American Foundrymen's Association will hold their annual convention and exhibit in the Cleveland Auditorium, April 28th to May 3 inclusive. The exhibit will open on Saturday, April 28, while the Convention will not start until the Monday following. Saturday, April 28th, the opening day, will be Cleveland Day for the inspection of exhibits, but the exhibit will not be open to the public on Sunday.

The United States Civil Service Commission announces an open competitive examination for instrument makers. Vacancies under the following departments are to be filled from this examination, unless it is found in the interest of the service to fill any vacancy by reinstatement or transfer or promotion. The following bureaus are listed as having vacancies for instrument makers. Coast and Geodetic Survey, Naval Observatory, Office of Secretary of Agriculture; The Bureau of Standards, Department of Commerce, Weather Bureau.

Applications for this examination will be received until December 30th, 1922.

Further information may be obtained from the United States Civil Service Commission, Washington, D. C.

The Weldless Rolled Ring Company of Cleveland has recently been organized by former executives of the Washington Steel & Ordnance Company and offer the benefit of their knowledge and experience in your use of rolled circular sections in steel and non-ferrous metals.

This Company will roll various types of weldless rings under patents and equipment acquired from the Washington Steel and Ordnance Company.

The United States Civil Service Commission announces an open competitive examination for structural steel work draftsmen. Two vacancies at the Naval Operating Base, Pearl Harbor, Hawaii, are open; one at $7.20 per diem and the other at $7.60 per diem, each with an additional allowance of 96c per diem while employed at the station; a vacancy in the Public Works Department, Naval Station, St. Thomas, Virgin Islands, at $6.80 per diem; and vacancies in positions requiring similar qualifications, including the Departmental Service, Washington, D. C., at these or higher or lower salaries, will be filled from this examination, unless it is found in the interest of the public service to fill any vacancy by reinstatement, transfer, or promotion. Applications will be rated as received until December 29, 1922. Applicants should apply at once for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.

The Pangborn Corporation of Hagerstown, Md., announced a new sand blasting device having the following description:

A new barrel just introduced by the Pangborn Corporation of Hagerstown, Md., embodies features that have taken into consideration economy of operating cost, from the viewpoint of both increased efficiency of blasting action and durability of the equipment itself.

Experience has shown that cleaning capacity in sand-blasting is governed by the distance of the nozzle from, and its angle to the work. To accommodate varying classes of work with the changing sizes of the individual pieces and the corresponding "ride" within the barrel drum, the nozzles are made adjustable in both horizontal and vertical positions to secure the most effective position.

A mechanical separator assuring constant and perfect separation of the abrasive for reuse is obtained by a ribbed roller driving against a shaft protected by heavy rubber tubing. This tubing takes the entire wear and is quickly and cheaply replaced.

Long life for the equipment is provided in every moving member. The barrel drum is reinforced at door opening with plates and angles inside and outside; steel tires pinned to head castings and driving on manganese steel rollers, with front rollers idle and equipped with roller bearings, provide smooth even traction with little wear.

Driving sprockets are steel and with chain run in oil bath, all encased dust tight.

The clutch is simple and positive acting, and will not get out of adjustment but insures satisfactory service at all times.

Two sizes with drums 30 x 40 and 50 x 40 make it available for work from small to as large as is feasible for barrel cleaning.

Many points of vital interest are reviewed in the publication of the Metal & Thermit Corporation entitled "Reactions." This publication deals largely with Thermit welding of material. Thermit welding serves a very valuable purpose in repairing broken parts of large and cumbersome machinery, such as locomotives. It also serves a very fine purpose in the welding of steel rails. The current edition of "Reactions" is profusely illustrated with pictures taken of equipment under construction and repair.

Arthur H. Hunter, president of the Atlas Steel Corporation has resigned his active connection with the corporation, effective November 1. Mr. Hunter was formerly president of the Atlas Crucible Steel Company, and since the amalgamation was president of the new company. He will remain as a member of the board of directors.

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